Routledge Spatial Humanities Series

MODELLING THE CITY

FORMAL ONTOLOGY AND SPATIAL HUMANITIES

Edited by Wiesława Duży

Modelling the City

Modelling the City focuses on European towns and cities, analysing the opportunities and limitations of modelling of urban space.

This book examines how urban space from the past is discovered, explained and presented. It discusses the multitude of historical sources mediating the past urban space, and the structural, technical, and epistemological issues raised around building a domain ontology, including continuity, and change within urban forms and functions.

Presentation of a formal domain ontology in spatial humanities makes this book unique and worth reading. It is strongly recommended to readers interested in the linked open data approach to research, data standards in Digital Humanities, urban planning, and old maps.

Wiesława Duży is Assistant Professor at the Department of Historical Atlas at the Institute of History, Polish Academy of Sciences. She is also part of a project at the Faculty of History, "People, Places, and Events" of the University of Warsaw, Poland. Her research interests include social history of the eighteenth and nineteenth centuries, domain ontologies in the Humanities and spatial historical databases.

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Formal Ontology and Spatial Humanities

Edited by Wiesława Duży

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Introduction

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How to build a solid house, or about the historical ontology of the urban space project

Wiesława Duży

The book is one of the research outcomes of the project "Historical Ontology of Urban Space" (HOUSe) led by the Institute of History, Polish Academy of Sciences, and involving project partners from around Europe. The book reflects the discussion on modelling historic urban space which had been engaging us since 2019 onwards. The scientific aim of the HOUSe project was to investigate possibilities of analysing past urban space by means of the formal domain ontology (also referred to as "urbanonto ontology"). Apart from building an ontology, we also decided to design a relational database, the Urban HomeBase, for three general purposes: 1) collecting spatial data, 2) testing ontology-driven data model, and 3) discussing the chances and obstacles connected with dataset presentation. All this would not be possible without a general overview of building domain ontologies for modelling spatial phenomena, nor without a discussion on the access we have to past realities through various media. In the book, we also assume responsibility for discussing urban space in its full scope – not only as a physical phenomena with its morphological features, but also as a result of human activities – and thus we assign value and/or names to this space. This approach would be unfeasible without a broader reflection on the digital spatial humanities and specific case studies derived from the considerable experience of the Historic Towns Atlas (HTA) series.

The aim of the volume is to discuss, among others, a multitude of historical sources mediating the past urban space to current explorers and users, and difficulties brought by this variety to all aiming for harmonisation, standardisation, and comparativeness. We also discuss structural, technical, and epistemological issues raised around building a domain ontology, including continuity, and change within urban forms and functions. Selected case studies collected around the core issue – discovering, explaining, and presenting urban space from the past – enrich the discussion.

Three parts build the book. "Media, sources, data model" discusses modelling in humanities so as to shed light on this field of research and related hermeneutical approaches. This book section presents three studies centred on the following: media-dependent understanding of historical reality; formal ontology of spatial phenomena, along with a discussion on applying physical objects from the past to a model based on objects represented on old maps; an extensive example showcasing

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how the ontology-driven approach can be used to discover, understand, and explain fragments of the past.

Issues addressed in the second part of the book "Investigating urban space" are identity and changes of forms, functions, and locations within the built environment of historical towns. Urban space was always made up of interconnected physical objects, which reflected social relations and needs, along with economic and technical possibilities. Because of all these contingencies the urban reality was dynamic, and time was a dimension mutually interwoven within the fabric of material forms in space. Those issues are discussed from three angles: changes over time influencing perception of urban space and its identity, naming as an important factor of the construction of space, and representation of past urban space in Urban HomeBase and in Historic Towns Atlas series.

The third part of the book "Mapping objects in urban space" focuses on the link between media and historical reality. Here, we thematise some reflections on the practice of urban historians and geographers. When looking at a historical town or city through available media, can we anticipate discovering any elements of the dynamic set of relations in space and related to space? To what extent can the individual features of objects, their perception and categorisation in the past be possibly conveyed through these media, and to what extent did simplification and generalisation hinder or foster the survival of all those singular objects, and in particular the lived experience of space? What opportunities and obstacles arise from the ontology-based data model for spatial research?

Each part of the book consists of three chapters. Øyvind Eide starts with establishing mapmaking as a modelling process which can be based on different principles than creating a model of the territory existing in a local context of the construction of the map. Eide also discusses mapmaking in a semiotic context as well as by various media of a map.

Francesco Beretta brings us a detailed discussion on building and linking formal ontologies. He asks the question if the CIDOC CRM (CRM for Conceptual Reference Model) can be used as a conceptualisation situated between foundational and domain ontologies. Beretta also discusses the importance of adopting the foundational perspectives of the DOLCE and *Descriptions & Situations* ontologies. The chapter discusses subtle, yet fundamental, differences between modelling the past reality as a physical entity available through various source media and as a representation of the past in those sources. The aim of Beretta's writing is to ground a transdisciplinary model of geographical places.

From the very beginning of the HOUSe project, we were aware that the overarching perspective for this project is not to provide a finished, stable, and closed product of domain formal ontology but rather to build a capacity of discussing this approach among the most important institutions and researchers interested in the topic in Europe. Discussions we had during the project included various approaches and arguments derived from other research and experiences to enrich our discussion and to provide more material for meeting compromises. Therefore, I am more than happy that Paula Aucott and Humphrey Southall shared their work with us. In the chapter focusing on identifying

key features within the urban landscapes, they were able to present an alternative perspective of ontology building. Southall and Aucott, instead of taking a modern dataset and using experts to extend the information to incorporate historical elements and features, explore the information provided within a historical source itself, and offer an alternative starting point for categorising urban features.

Tabitha Redepenning decided to contribute with a chapter on representation of urban space in guidebooks. This chapter is indeed unique and therefore broader introduction is needed here. The reason I consider the chapter this way is as follows. Redepenning gives the reader perspectives of both: a researcher, whose task is to dive into urban space as deep as possible to understand it and explain it, and a creator of the sources, being a medium for those researchers to reach the deep. Presenting on one hand the activities of the guidebook user, almost embodying the acquaintance with the urban space, as well as a conceptualisation of these books on the other, Tabitha Redepenning found a way to consolidate those perspectives in one coherent narration. Carefully selected as a case study, Szczecin, a town facing massive changes in political, social, and even morphological aspects of its existence, allows the author to give readers a multifaceted view into urban studies. I am particularly happy with this chapter, because by dissecting the urban space from the touristic point of view the author managed to show the various aspects of its representation. We can read in the chapter that space representation and attribution of meaning often goes beyond national narratives and draws longer lines in urban development. How the city is seen and the districts are divided does not change with its nationality. Tabitha therefore shows the underlying attribution of meaning which "goes without saying." The chapter beautifully illustrates how elements of the city get increasingly complex meanings assigned, starting from the simple accumulation of points to historicising whole districts by communicating its time element.

The constitution of urban space may also be effectively explored via the history of geographical names. Place names, street names etc. were changed to the respective national or ideological ideas. Grigori Chlesberg in a following chapter aims to explain the acquisition and construction of space by different political actors. To reach this aim, Grigori investigates the changes of geographical names in the nineteenth and twentieth centuries in two present-day Republic of Poland cities: Poznań-Posen and Gdynia-Gdingen-Gotenhafen.

Authors of the chapter discussing the HTA series and research procedure from the HOUSe project focus on the fuzziness of urban space to give us a picture of the perdurant yet not always easy to categorise phenomena. Materials they analyse and explain to us are massive and diverse, and therefore complicated to standardise and build models. Anna-Lena Schumacher, Michał Słomski, and Daniel Stracke gave us, despite all odds, an extremely rich and informative chapter with possible solutions and future questions concerning the digital shift in historical research.

Katarzyna Słomska-Przech and Wiesława Duży are discussing construction and validation of urbanonto formal domain ontology built as a part of the HOUSe project. UrbanOnto is an ontology that models the world (historical town space), taking

into account its potential changes in time. Thus, validation does not concern the model and the world (1:1 relation), but the model and representation of the world in the source. Hence, use of the whole model made of three ontologies requires interpretation by a domain expert.

We also invite our readers to investigate more details about the analytical power of ontology-driven modelling in chapters on the results of comparative studies which looked at Warsaw plans and British Ordnance Survey maps. This discussion by Katarzyna Słomska-Przech and Keith Lilley gives us a concise and deepened example of introducing standards to urban studies.

A similar (comparative) perspective can be observed in the last chapter of the book. Old plans of Lviv, a town in Ukraine, are, however, used to investigate urban development over time. Again, a key of symbols built with an ontology-driven data model facilitates interpretation and presentation of urban history. We hope that the chapter by Marta Demchyna, Katarzyna Słomska-Przech, and Tomasz Panecki will be a handy scenario for further research on urban heritage.

Therefore, the main idea of the book is to discuss the opportunities and limitations of modelling of urban space which prevails and evolves over time. We invited scholars of various specialisations to contribute their knowledge and experience to the discussion on urban space in the past. We focused on European towns and cities in line with the organisational framework of the Historical Ontology of Urban Space project and our research scope, which included the above mentioned Historic Towns Atlas series. We hope to spark the interest of our readers, as we believe that many of the issues discussed here are applicable to Europe and North America's industrial and technological development of the nineteenth century which influenced both urban space and the produced cartographic material that is now used in urban studies and its source editions. Last but not least, let us highlight the reason why this is possible and necessary. We conduct all our considerations within the technical and conceptual framework of GIS. Not forgetting about the broader picture, we focus on issues imminent containing geodata and references to geographic information systems with specific examples. Thus, we place the book within the spatial humanities domain.

The book has been published with financial support from the Polish National Agency for Academic Exchange as a result of the project Historical Ontology of Urban Space (project no. PPI/APM/2019/1/00053/U/00001). The editor also thanks the Foundation of the Institute of History, Polish Academy of Sciences, which supported authors at the very final phase of the book production.

Part I

Media, sources, data model

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1 Modelling as a bridge between maps, spatial concepts, and the territory

Øyvind Eide

Maps as models

A map[1] of a territory is a model of the territory, but this model exists in a local context of the construction of the map. Modelling is always pragmatic in the sense that a model is created by someone with a purpose, and it is used by someone for a reason.

This chapter will establish mapmaking as a modelling process which can be based on quite different principles. Furthermore, the terrain being mapped is always seen through the eyes of the mapmaker. The territory does not have to exist in a material sense, as we see in the mapping of fictional and mythical landscapes. In historical mapping, the landscape being mapped does not exist, but the map is still expressing hypotheses about a possible landscape, or cityscape, that is assumed to have existed at some time and place.

Creating a map is a rhetorical act. It establishes a claim for a landscape. This claim can focus on a physical landscape used as a basis for the map. In this case the map is a *map of (model of)* the landscape. The claim can also be to a yet non-existing landscape created through the map. Then it is a *map for (model for)* a landscape.[2] In some cases this landscape later gets a material interpretation, as in map-based city planning. In other cases, it remains fictional in the sense that no physical landscape is related to the map. The map always refers to something, but in this case what is referred to can, for instance, be the fictional world of a novel. All models are both models of and models for, but the focus is often on one or the other.[3]

Maps are never pure models of landscapes. They are always made by someone for a purpose, and express a specific perspective on the landscape. The truthfulness of a map as a representation of a landscape can be empirically tested, whereas the selection of elements represented is based on choices made by the mapmaker. The fact that many of the choices are scholarly based, often even indisputable, gives them a certain level of objectivity, but they are always choices that could have been made differently.

In certain types of orienteering maps, a black dot represents a boulder. The definition of a boulder can be "a rock in the landscape which stands out from the ground on all sides and has a height of more than one meter." The relation to the landscape

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and the height of a physical thing can be analysed and measured in order to find out if something is a boulder. But the choice of definition of a boulder is not an empirical question, it is rather part of the constitutive rules for the map creation process.[4]

The rules for the selection of features for maps are better known for some types of maps, such as orienteering maps, than for others. The systems on which some historical maps are based are well known, whereas in other cases that is not the case and the rules have to be reconstructed in order for the claims about the landscape they were based on to be understood. The rules that were used to construct a map can be more or less known, as can the intention behind map construction.

Another way of analysing maps is to check the map against the landscape, which can help us reconstruct the relationship between map and landscape empirically rather than rhetorically. For modern maps, this process can be quite precise and is a way to evaluate the quality of a map. For historical maps this is harder, as the landscape no longer exist as it was when it was the basis for the map. In the analysis of such maps, the documents that were maps of a landscape transform into a map for the reconstruction of a historical landscape, and move in the direction of *maps for* ("*model for*") the establishment of a landscape.[5]

Thus, when historical maps are used to make arguments about historical landscapes, empirical investigations are combined with a constructive understanding where the process of making the map is reverse engineered. We will come back to this aspect below. Before that, we will use two complimentary light sources to illuminate maps as models: semiotics and mediality. We will also see that neither of the two is a single source of illumination, they both express a complex set of possible lighting features.

The semiotic lights

The relationship between maps and territories is always influenced by this pragmatic context of internationality. In the analysis of the semiotics of maps,[6] the syntax of the map (the spatial relationships on the map) and the semantic function (the link to the territory) are completed by the pragmatic function (the link to concepts in the minds of map creators and users). Map creation is a complex semiotic activity where meaning is negotiated, selected, modified, and organised based on a subjective understanding of the landscape combined with rules and systems adding a level of objectivity and testability, which always have to be balanced against the need of expressing the fuzziness, uncertainty, and underspecification of the sources, contemporary as well as historical.[7]

In a semiotic understanding of modelling more generally, the specific relationship between a model and the model target, i.e. the processes or objects being modelled, is understood to be mainly iconic. Models are icons.[8] How does this relate to the complex semiotic system of maps, where also symbols and indexes are important? In order to clarify the difference between map semiotics and a semiotic analysis of models, we need to understand that we are talking about two different ways of analysing maps, one view based on intrasignification and one based on

extrasignification. When Wood[9] describes the map as a cultural sign in society with tendencies towards myth, the focus is on the map as a whole working as a sign. This view, based on the extrasignification of maps, is what we also find in the semiotic analysis of modelling, where the model as part of a larger modelling process is seen as a sign.

The relationship between the map as a model and the landscape (real or fictional, contemporary or historic) is an iconic one. The maps express a complex iconic relationship which is located in the span between image-like and structural similarity. Maps are usually not pictorial at the level of a realist landscape painting, but neither structural at the level of a mathematical formula. Taking a step back into the data behind digital maps, we see that raster maps where the raster image is a scan of a paper map carries the iconic complexity over from the original paper map, whereas the data behind a vector map mainly has structural relationships to the depicted landscape. The map as a whole represents the landscape through a set of iconic relationships of different complexities, establishing the map as a general complex icon when we see it as a model of a real landscape, or a model for a fictitious landscape, which can be planned to be created in the future, as in city planning maps.

In the semiotic view on maps we know from map semiotics,[10] the map is, as mentioned above, connected to a complex interplay between syntactics, semantics, and pragmatics. This is not too different from the iconic view on models, where the pragmatic aspect is also important, and where the syntax or syntactics of a model is important to understand how it works, and where the semantics is the basis for the iconic understanding. The main difference is that in map semiotics, the focus is on the intrasignification of the map. We are opening up the map document in order to study how each specific part of the map relates to other parts, to the depicted real or fictitious world, and the concepts carried by the human map creators and users.

In this view on maps, the sign system includes a mix of complex signs where some are dominated by symbolic and some by iconic aspects, all carried by an indexical net (or grid), where the relationships are not only between each sign on the map, but where also the empty, or white, parts of the map are important, as a claim that there is nothing relevant to the mapmaker at such locations.[11] Each position of the map represents a position in the landscape, where place names are examples of mainly symbolic signs representing the specific place on the map, which is linked to a particular place in the landscape, connecting it to the name of the place.

A map sign can represent the form of a landscape feature through its form, as a mainly iconic sign, e.g., when the form of a house on the map is similar to the form of a house in the landscape. Even if the landscape does not exist, the iconic form claims a similar form in the unreal or non-existing landscape. A cross-formed building can represent the cross-shaped form of a church, but can also represent a church with a quite different form, where the cross has mainly a symbolic aspect as a sign of Christianity representing a Christian building. The map signs relate syntactically to other signs, partly by geometrical relationships of direction and distance, which iconically represent similar directions and distances in the landscape based on the scale of the map, but also connect the map sign to other similar

signs belonging to the same type of map signs, e.g., any church represented with similar signs wherever they may be located on the map.

Pre-existing knowledge representations are brought to bear on the interpretation of visual scenes, also in maps, through knowledge schemata serving as an interface. The schemata structures what we know and what we see, but what we see also provides input to the schemata. There are three general types of schemata that form a basis for how we categorise propositional, image, and event schemata. This means that we are mapping individuals we encounter to schemata entities.[12] Further research, including user studies, presents more evidence on how users actually understand maps.[13]

MacEachren further suggests that humans possess a general map schema, including at least these principles: (1) position on map linked to position in space via some coordinate system, (2) a map space represents a geographical space within some size range, (3) the space depicted is continuous and hierarchically structured, including consistency of distances, (4) point, line, area objects exist in space and are represented in schema, (5) graphic primitives linked to these variables represent them, (6) relationships between graphic primitives ensure the alikeness of symbols which look alike the locations, (7) the scale of map marks is independent of the map. This general map schema is presumed to be held at varying levels of detail by most adults. Specific map schema developed by using the general schema (or another specific one) to identify something as a map, then note what does not fit the general schema.[14] The degree to which schemata are indeed general can be discussed, but it has been shown that there are common cell structures in the brains of several mammals, presumably including humans, that seems to be consistent with such a view.[15] We will come back to this question below.

A map, with its signs belonging to types and occupying positions on the space of the map, is created based on knowledge of the landscape which is identified in different ways including triangulation, aerial or satellite images, and land survey. The collection and organising of the sources for the map is also a process of data modelling, where features in the landscape are identified, selected as relevant to the map, and divided into types through identification of similarities and differences. Data modelling is a process in which source material is organised and interpreted in a way which makes it possible to establish data representing the sources.[16] As in all data modelling, the data are strictly speaking capta as defined by Drucker.[17] In Geographical information systems (GIS), each map sign is represented as a database record connected to a spatial expression, usually representing a point, a line, or a polygon. Data modelling as a basis for establishing maps is not always explicit, but it always takes place. On the basis of the modelled data, a document is created which is the map as a media product.

The mediality lights

The map as a document is a media product with a set of modalities, thus, able to express certain aspects of reality.[18] A GIS database with spatial information is also a media product. When the map is based on data in the GIS system, the two media

products are related, but they are still not the same, and their ability to express information differs. The aspects of reality we can express can be increased through the creation of multi-modal complex documents consisting of not only data sets and maps, but also other media. Based on the configurations of these media products they can be called GIS systems, deep maps, databases with a map interface, illustrated textual documents, or other things. As we will see below, they are all geocommunication systems.

In the model of media in Elleström,[19] each media product has a certain configuration of four media modalities.[20] The material modality is the latent corporeal interface of the media product. This potential for a material interface is released when it meets the senses of a user. Typical modes of this modality are human bodies, other demarcated materiality, and not demarcated materiality. The material modality of maps has a demarcated materiality in the form of two-dimensional documents that can be conveyed by different carriers: paper, vellum, computer screens, or mobile phones. Paper and vellum are able to carry a fixed set of static maps, whereas computer screens and mobile phones has a wider use area as material interfaces and can hold an unlimited number of different maps, as well as other types of media products. The way one interacts with the maps also varies across different carriers.

The sensorial modality has five central modes: seeing, hearing, feeling, tasting, and smelling. Maps have a strong focus on seeing, even if tactual or raised image maps are also readable through braille or bold print, which is intended for feeling. Tools where maps form a central part, such as route finding systems, also include hearing.

While the sensorial modality of maps is quite simple, the spatiotemporal modality is much more complex. In this modality, the sensorial interaction with the material interface is linked to the semiotic meaning-making in the mind of the receiver. For both space and time, there are three main modes. Space can be manifested in the material modality, which is clearly the case for maps. There is always a cognitive space in a media product. Based on this, there is a potential for a virtual space. Virtual space is the main way of spatial configuration in texts. The form similarity between map and landscape often makes this mode less relevant for maps, but for certain features, such as contour lines, the space expressed has a stronger virtual nature than e.g., in the case of the curvature of a road.

Traditional static maps do not have time manifested in the material interface, but computer-carried maps often have such manifestations of time, usually in the form of a less fixed time of interactive maps, but it can also be in the form of fixed time in moving maps, for instance video maps showing changes of borders over time. Perceptual time is always present; all media products are engaged with in time. Virtual time is often created by maps, for instance in the form of arrows and texts on a map showing military operations. When storytelling is based on maps, the performative media product of the storytelling has time manifested in its material interface.

The semiotic modality is based on the three main modes we know from map semiotics: symbols, icons, and indexes. Maps have a complex set of signs where

either of the three can be dominating, as we saw above. Further to that, the extrasignification aspects of maps have a different semiotic function from intrasignification.

It is important to note that there is no order of the modalities, it is not the case that map use moves through the modalities ending with semiotics. The modalities and their modes are analytical categories which represent aspects of a complex and mixed process, where semiotics plays a fundamental role mixed together with the other three pre-semiotic modalities. In order to expand on the understanding of maps into a wider view on both understanding of existing maps and other tools for spatial reasoning, and the potential for creating media products to express such reasoning, a wider view on media is necessary. This will be subsumed under the concept of geocommunication.

Understanding spatial historical knowledge

Geocommunication is a basic concept for Brodersen[21] in his work on the semiotics of maps and other forms for communication of geographical information. For Brodersen, maps form a subset of geocommunication. Communication is about influencing the user. In order to establish a rational fundament for geocommunication, he sees a need to examine the "reality," including the relationship to the user. Geoinformation is the set of located information available to the user, of which she can extract some meaning. An example of this would be a directional service, which consists of maps, driving time, distances, etc. The purpose of establishing such a geocommunication system is to enable the user to make decisions as a basis for acting in space and time. The set of geoinformation lays the basis for better decisions than maps alone. By adding elements with different configurations of media modalities, a potential for expressing a wider set of aspects can be reached.

The geocommunication process is based on an exchange of signs, it is also a semiotic process. Geographical maps refer semantically to a landscape, but pragmatically to a conceptual thinking system. This creates a basic ontological problem. The quantitative cartographic tradition is different from the qualitative view on geography in human thinking and communication. This difference is well-documented and must be acknowledged in order to clarify the ontological understanding in thought and communication.

> In contrast to the ontologies underlying most geographic information systems, which rest on discretized metric world models, such an ontology must have the resources to represent the *qualitative* conceptual categories conveyed by natural language.[22]

This task is challenging enough for contemporary understanding as it is expressed in communication and can be investigated through empirical studies.[23] Historical spatial ontologies pose a different level of problems and the sources to study them give few clear answers.[24] This is indeed one of the core questions the HOUSe project grapples with, and will be an underlying question in this volume as a whole. While the understanding of map symbols is widely

shared, all of them are not understood identically by everybody. The legend in the perimap of many maps defines the meaning of symbols, but a legend is not always present and, even if present, it is often not complete.[25] Maps are semiotic artefacts in the sense that understanding them always involves sign interpretation, and sign interpretation is never independent from the person doing the interpretation.

This begs the question if ontologies can form a basis for historical and even contemporary understandings and communication of geographical knowledge. Based on a phenomenological view on geocommunication, together with a view on maps as models based on a semiotic and a media-based understanding of modelling, it is hard to see the meaning of maps as being general, a problem we also see in MacEachren's concept of "map schemata."[26] Meanings are based on a context in time and space as opposed to only one general meaning. All landscape observation or use, with or without maps, are connected to an embodied sense experience, which takes part in the establishment of spatial knowledge. The experience is an event, in which sense impressions are synthesised, forming an understanding of specific places as well as types of landscapes.[27] Any description of an object is simpler than the object. It is based on a subset of possible properties; any experience or model of the landscape is simpler than the landscape itself. As the map is a model of the landscape, so is the spatial understanding of a user of the landscape, as well as the spatial understanding of the one only knowing the landscape through maps.

For it is a basic aspect of landscape knowledge that it is known based on real landscapes also when we have never seen the actual landscape in questions, indeed also when the landscape is fictional, as for the island of Robinsons Crusoe's last shipwreck.[28] We know also the unknown landscapes, and the landscapes we only know through maps or other sources, partly through our own landscape knowledge. Indeed, the knowledge is local and personal, and based on the context of each single event in a single person's movement through the landscape and media products.

If this view should stand, however, we need to address the question of how we can communicate at all. Personal views are important, but many things are shared. And context is a spurious concept. In map reading, as well as in landscape experience, the potential context is unlimited, it can include "just about anything in the circumstances of the utterance, and just about anything in the participants' knowledge or prior or current expertise."[29] However, in real situations the actual relevant context can be quite limited. The problem is not as much specific contexts being unlimited, but that the possible relevant parts of the context, limited as they may be, are hard to identify even in particular situations, and close to impossible as a general rule.

More concretely: in a situation of governmental or imperial mapping, a large set of information is gathered. All this information is created through events that take place in time and space. The construction of the map is targeted at making time and the particular aspects of the events in which data was collected not only irrelevant, but also invisible; "the drawing of the map gives materiality and objectivity to space, endowing it with an additional degree of reality,"[30] and even if the map is a visual memory of discourses, time is frozen in the map. While the narrative

happened in time, the map is outside of time. Not as a physical object, but in its meaning-making rhetoric, and, as we saw, in its media modalities.

In order to reconstruct the history behind the map, geocommunication as a whole has to be taken into consideration. Seeing the whole geocommunication situation also means that we can develop a better understanding of the tools used to present historical knowledge in maps. We can express our knowledge as one or more static maps alone, but if we move into richer multimodal expressions we have a potential of stating our claims about the past in a fuller sense. Not necessarily fuller in the meaning of being more correct or precise, but rather fuller as in presenting more aspect of our claims, making them more open for discussion and alternative stories.[31]

Further discussions of the modelling of physical space versus modelling representation of the space such as a map can be found in Chapters 2 and 7. This point will also be further exemplified in Chapter 6, where examples of maps of urban-growth phases from the Historic Town Atlases series are used to show how difficult it is to show development and a change over time in a static two-dimensional map. In this way, we can develop further tools for historical analysis of landscapes and cityscapes while also including different layers of space conceptualisations, from the conceptual models underlying the information systems themselves to hypothetical understandings of historical spaces and their conceptualisations. An example of this we can find in the study of changes in the urban landscape over several centuries in Chapter 9.

With creative use of two- and three-dimensional visual representations, text, and images, but also time-based media such as audio, video, and visual narratives i.e. comics, cartoons, and virtual reality, the mapmaker-gone-multimedia-artist can express a rich set of historical understanding, and the information systems can be used for hypothesis testing by adjusting variables and presentation forms. Such dynamic geoinformation systems have a potential far beyond the presentation of knowledge. They can become tools for creative spatial thinking, which can be used as part of historical research. They never represent history directly, but can draw from source-based understandings of history. In Chapter 4, city walks are used to explore how highlighting certain elements of the urban landscape and connecting them with each other is used to express certain desires or desired perceptions of the city image by different actors through narratives. "Narrative" is understood here as the overarching story that explains and provides meaning to individual elements, in this case urban landscape elements.

There have been several calls for moving beyond the Cartesian systems for mapmaking.[32] One way of operationalising such a move is to create interactive online geocommunication publications in which the map panes form part of the whole publication, together with texts, comics, network visualisations, animations, and other parts in different media. Creating such systems is not new, as many digital deep maps are already doing this. It is important in such systems to see the media modalities as a set of limitations for how each part of the system can express aspects of reality. "Every medium has the capacity of mediating only certain aspects of the total reality."[33] Therefore, it is important to include analysis of how

different media, for instance, texts, maps, and virtual reality systems, each can express aspects that the others have a harder time expressing.[34] This does not mean that media borders should not be pushed, it is rather an acceptance of the fact that even when trying to extend what can be expressed with a map, a text, a comic, or a virtual reality system, there are both technical and medial limitations to how far one can go. The possibilities are also always limited by the ability to understand the message on the side of the receiver.

Looking at the history of cartography we see that attempts to extend the borders, to create complex geocommunication systems, are indeed not new. They are partly expressed in single publications, such a historical atlases using texts, maps, and series of maps to tell a richer story, but maybe more importantly in the use of different media products at the desk of the researcher, whether the research is academic or is done in other settings.[35] Examples of such complex geocommunication systems are common, also in this volume.

Notes

1 The term "Map" used here refers to two-dimensional objects depicting a real or fictitious landscape. For a deeper discussion on map definitions, see: Øyvind Eide 2021, "Where Is the Map?" in: *Mapping the Unmappable? Cartographic Explorations with Indigenous Peoples in Africa*, edited by Ute Dieckmann, pp. 47–68. Bielefeld: Transcript. https://doi.org/10.14361/9783839452417-003

2 On the distinction between *model of* and *model for*, see: Clifford Geertz, *The Interpretation of Cultures: Selected Essays*. Book. ACLS Humanities E-Book. (New York: Basic Books, 1973) pp. 93–94 and Willard McCarty, *Humanities computing*. (Basingstoke: Palgrave Macmillan, 2005) p. 27.

3 Bernd Mahr, "Information science and the logic of models." *Software & Systems Modeling* 2009 8 (3): 365–383.

4 Øyvind Eide, *Media Boundaries and Conceptual Modelling: Between Texts and Maps.* (Basingstoke: Palgrave Macmillan, 2015) p. 22.

5 On different levels of testability of different types of maps, see the research blog post *Text to Map: Rooms of Possibilities.* https://modmebo.hypotheses.org/36

6 Alan M. MacEachren, *How Maps Work: Representation, Visualization, and Design*. 2nd ed. (New York: Guilford Press, 2004).

7 Empirical research on the visualisation of uncertainty and how it is understood by map users is not only an interesting question in itself, having consequences for what enables good map communication, but it is also bringing the discussion on what enables us to understand maps more generally forward, see: Alan M. MacEachren et al., "Visual Semiotics & Uncertainty Visualization: An Empirical Study." *IEEE Transactions on Visualization and Computer Graphics* 2012 18 (12): pp. 2496–2505. https://doi.org/10.1109/TVCG.2012.279

8 Björn Kralemann and Claas Lattmann, "Models as icons: modeling models in the semiotic framework of Peirce's theory of signs." *Synthese* 2013 190 (16): pp. 3397–3420.

9 Denis Wood, John Fels, and John Krygier, *Rethinking the Power of Maps*. (New York: Guilford Press, 2010).

10 Alan M. MacEachren, *How Maps Work: Representation, Visualization, and Design*. (New York: Guilford Press, 2004).

11 Eide, *Media Boundaries and Conceptual Modelling: Between Texts and Maps,* p. 126.

12 Alan M. MacEachren, *How Maps Work: Representation, Visualization, and Design,* pp. 150–151.

13 Robert E. Roth et al., "User Studies in Cartography: Opportunities for Empirical Research on Interactive Maps and Visualizations." *International Journal of Cartography* 2017 3 (sup1): pp. 61–89. https://doi.org/10.1080/23729333.2017.1288534
14 Alan M. MacEachren, *How Maps Work: Representation, Visualization, and Design*, pp. 198–202.
15 See: e.g. Richard J. Gardner et al., "Toroidal Topology of Population Activity in Grid Cells." *Nature* 2022 602 (7895): pp. 123–128. https://doi.org/10.1038/s41586-021-04268-7 for a recent contribution on this topic. See: Øyvind Eide, *Media Boundaries and Conceptual Modelling: Between Texts and Maps*. (Basingstoke: Palgrave Macmillan, 2015) pp. 34–35 for a discussion of the connections to historical conceptualisation of space.
16 Julia Flanders and Fotis Jannidis, *The Shape of Data in the Digital Humanities* (London: Routledge, 2018), https://doi.org/https://doi.org/10.4324/9781315552941
17 Johanna Drucker, "Humanities Approaches to Graphical Display." *DHQ: Digital Humanities Quarterly* 2011 5 (1). http://centerforethnography.org/content/humanities-approaches-visual-display
18 Lars Elleström, "The Modalities of Media: A Model for Understanding Intermedial Relations," in: *Media Borders, Multimodality and Intermediality*, edited by Lars Elleström, pp. 11–48. (Basingstoke: Palgrave McMillan 2010) p. 24.
19 Lars Elleström, "The Modalities of Media II: An Expanded Model for Understanding Intermedial Relations," in: *Beyond Media Borders, Volume 1: Intermedial Relations Among Multimodal Media*, edited by Lars Elleström. (Basingstoke: Palgrave, 2021).
20 On a more extensive discussion on media modalities for maps, see: Øyvind Eide, *Media Boundaries and Conceptual Modelling: Between Texts and Maps*, for modelling, see: Arianna Ciula et al., *Modelling Between Digital and Humanities: Thinking in Practice*. (Cambridge: Open Book Publishers, 2023) ch. 4.
21 Lars Brodersen, *Semiotik i geokommunikation: fra virkelighed til handling*. (Fredrikshavn: Tankegang, 2005).
22 Mark, David M., Barry Smith, and Barbara Tversky, "Ontology and Geographic Objects: An Empirical Study of Cognitive Categorization," in: *Spatial Information Theory. Cognitive and Computational Foundations of Geographic Information Science*, edited by Christian Freksa and David M. Mark, pp. 283–98. (Berlin, Heidelberg: Springer-Verlag 1999). Italics after original.
23 See: e.g. Barbara Tversky and Paul U. Lee, "Pictorial and Verbal Tools for Conveying Routes," in: *Spatial Information Theory: Cognitive and Computational Foundations of Geographical Information Science: International Conference Cosit '99, Stade, Germany, August 25-29, 1999: Proceedings*, edited by Christian Freksa and David M. Mark, pp. 51–64. (Berlin: Springer-Verlag, 1999).
24 See: Chiara Palladino, "New Approaches to Ancient Spatial Models: Digital Humanities and Classical Geography." *Bulletin of the Institute of Classical Studies* 2016 59 (2): 56–70. https://www.jstor.org/stable/44254153 for a recent discussion of the situation for Antiquity, based on the use of digital tools.
25 Denis Wood, John Fels, and John Krygier, *Rethinking the power of maps*. (New York: Guilford Press, 2010) pp. 67–72.
26 Alan M. MacEachren, *How maps work: representation, visualization, and design*. 2nd ed. (New York: Guilford Press, 2004) pp. 150–51.
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31 Robert E. Roth, "Cartographic Design as Visual Storytelling: Synthesis and Review of Map-Based Narratives, Genres, and Tropes." Journal Article. *The Cartographic Journal* 2021 58 (1): pp. 83–114. https://doi.org/10.1080/00087041.2019.1633103
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34 Øyvind Eide and Zoe Schubert, 2021, "Seeing the Landscape Through Textual and Graphical Media Products," in: *Beyond Media Borders, Volume 2: Intermedial Relations Among Multimodal Media*, edited by Lars Elleström. (Basingstoke: Palgrave, 2021).
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2 An ontology of geographical places and their spatio-temporal, social evolution in the context of an ecosystem of CIDOC CRM extensions for humanities and social sciences (SDHSS)

Francesco Beretta

Introduction

The challenge of modelling the complexity of the spatio-temporal evolution of geographical places is well known to experts in the field.[1] Moreover, most geographical places relevant to Humanities and Social Sciences (HSS) are defined by social activity and collective representations, such as political and administrative territories, land ownership, and urban parcels, or are the result of human activity, such as settlements, houses, harbours, or highways. It is not only the contours and spatial projections of these places that are constantly changing as a result of human activity. Different claims to ownership or jurisdiction over the same territories, or the way in which boundaries are drawn, also lead to conflicts and confrontation. To this, one must add the difficulty for the historian of reconstructing these phenomena from sources which, on the one hand, bear witness to and provide access to the realities of the past and, on the other, act as a screen because they are often approximate or inconsistent. Sources often express views on places, their characteristics, and classifications, which may not be the same as today's. This reveals the different epistemic levels of geo-historical research, represented firstly by the reconstitution of the statements of the sources (factoids), be they texts, maps, or paintings; secondly by the production of information about factual reality, with all the approximations and choices it imposes between the possible variants of the same facts; and finally by the knowledge derived from the collected information in terms of the analysis of structures, causes, or evolutions present in the reconstituted factuality.[2] It is therefore essential to apply a mature modelling methodology that allows the development of an ontology capable of providing clear answers to these challenges. In this chapter, ontology does not mean the contents of a gazetteer with historical scope, nor a controlled vocabulary of place types organised in a taxonomy with different levels of abstraction, but a "set of representational primitives with which to model a domain of knowledge or discourse",[3] providing the essential classes and properties to describe the social and temporal evolution of geographical places. In other words, we are interested here in terminological knowledge (which can be expressed in RDFS or OWL-DL) and not in assertional knowledge (which is

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expressed using RDF).[4] According to a classic definition used in the field of digital gazetteers, i.e., structured dictionaries of places, geographical places are identified by three components: by recording one or more names of the place, by giving it a type (settlement, building, territory, etc.), by georeferencing it by means of latitude-longitude coordinates, or by using a bounding box.[5] While these elements are essential for identifying "place" objects, they only summarise and approximate extremely complex situations. On the one hand, there's the richness of the reality studied by the HSS, with all the complexity of the economic, social, political, and cultural situation that occurs around the place. On the other hand, different disciplines study different aspects from different angles of this complexity, which is often summarised by human geographers using the terms *location*, *locale*, and *sense* of place, respectively, expressing the geometric, physical, social, and emotional aspects that are the subject of scientific investigation.[6]

These different and generally inconsistent and less compatible approaches, views, and definitions of the notion of place and place identity can also be found in digital artefacts such as gazetteers, controlled vocabularies, and ontologies (e.g., Geonames, schema.org, or Wikidata) that represent places in information systems and on the Web. The analysis of discourse in geography, social science, architecture, and GIS science shows a great diversity of so-called place facets, those more oriented towards the spatial dimension of places and other concerned with the linguistic and emotional perception, leading to the question "whether place can be modelled by information science or not".[7]

In a stimulating paper reviewing the notion of place in different vocabularies and formal ontologies, Andrea Ballatore raises the relevant question of developing an ontology that "would help the modelling process of geographic information across domains". This author lists and discusses a number of elements and aspects – such as the ones we have introduced – that should be addressed in order to produce a model of place that is situated at "an intermediate conceptual layer between foundational and domain ontologies, enabling the interoperability of representations of place across academic disciplines, such as geography, history, and the digital humanities".[8] In the same perspective, we can observe that various authors have adopted the CIDOC CRM (ISO 21127:2014), a conceptual model and formal ontology developed for the purpose of data integration in the field of cultural heritage, as a possible response to the challenge of finding a common, high-level conceptualisation of the notion of place, capable of providing a common framework to the models and vocabularies of different approaches and scientific disciplines.[9]

In this chapter, I will adopt and further develop this perspective in order to assess whether the CIDOC CRM (CIDOC Conceptual Reference Model) can be used as a core conceptualisation situated between foundational and domain ontologies, providing a notion of place that can cope with the different issues mentioned above. In the first part, I will present a foundational and epistemological discussion of the modelling approach of the CIDOC CRM based on the OntoClean methodology. In the second part, I will apply this analysis to the classes and properties available in the CIDOC CRM itself (sometimes referred to as *CRMbase* and corresponding to the ISO standard) and its extension *CRMgeo* (not part of the ISO standard), to

model geographical places, and will address some methodological issues and missing aspects from the point of view of the HSS. In the third part, I will discuss the importance of adopting the foundational perspectives of the DOLCE and *Descriptions & Situations* (D&S) ontologies, and illustrate how the CIDOC CRM can be integrated into a broader core ontology for research, Semantic Data for Humanities and Social Sciences (SDHSS), to build on the robust aspects of the CIDOC CRM conceptualisation and add missing, relevant classes, and properties that allow for the integration of information from different scientific disciplines. In the fourth part, the *Geographical Place* and *Construction* classes are introduced to provide grounds for a transdisciplinary model of geographical places, while distinguishing and articulating it with the rich features of the social, economic, and cultural world with which places are associated, and with the various scientific classifications in different disciplines.

Finally, I will discuss some of the modelling issues raised in recent literature on similar questions and show how the proposed conceptualisation can provide a suitable framework for distinguishing the different aspects of the complexity of geographical places, and for clarifying what the semantic content of the available information is and how it can be appropriately modelled. Obviously, given the complexity of the topic, it is not possible to discuss all the issues and to offer a review of all existing literature. The aim here is rather to present some methodological principles and modelling solutions that could help to realise the aspiration, and scientific challenge, of aligning local models and domain ontologies to a common core model for the sake of interoperability and reuse in different scientific disciplines of the rich information captured in distributed information systems.[10]

Foundational and epistemological aspects of CIDOC CRM

We will consider here the last official version of CIDOC CRM (version 7.1.2, June 2022) for analysing the notion of place in this ontology.[11] But before doing so, we'll present some aspects of the OntoClean methodology developed by Nicola Guarino and Emil Welty as a "formal foundation of ontological analysis".[12] According to this methodology, classes are sets of entities that share properties in common. In OntoClean, properties primarily define the meaning of classes, their *intension*, while a class with all its instances, i.e., the entities that have a property, represents the *extension* of the property. In this context, *properties* are therefore used to define meaning, *intension,* and not a relationship between classes as in RDF. Properties allow to define the *essence* of entities: they are *rigid* if they are essential to all possible instances of a class and during the whole life of instances; or *anti-rigid* if they are not essential or only accidental, time-limited, or optional. If we take an example of a church, the property of being a building is essential to the entities of this class, and therefore *rigid*, while the property of being used for worship is not because in the life of this building it could be at some moment used as a stable or a disco. It must be noted that a class defined by a rigid property, like being a human, cannot be subsumed by an anti-rigid class, like being a student: "student" can only be a subclass of "human", and not vice versa. We can also observe that the property

of being a student for a person, as well as being a church for a building, does not appear to be an intrinsic quality of the respective entities, but an external classification or accidental use, and therefore does not define their essence.

According to OntoClean, properties can also provide criteria to discuss about the *identity* of entities: which properties or features allow to say that these two buildings are identical? Applying this methodology, one can say that if these two entities occupy the same place in a reference space and have the same appellation, they are the same entity. If this is true for buildings, is it also true for geographical places? If we recall the classical definition of places in gazetteers mentioned above, we can observe that while *location* and *appellation* can be considered as identifying properties, this is not the case for *type*, i.e., any extrinsic classification, or then only under certain conditions, i.e., the restriction of types to kinds that synthesise rigid properties of the object, as we will see below. OntoClean distinguishes "between properties that carry an identity criterion and properties that do not". The same applies to the notion of *unity* where properties allow to define if entities are wholes or parts of other entities. When we consider amounts of matter, such as water, they have no intrinsic criterion of unity and we can observe for rivers and oceans that it is the container, that is the Earth's crust, that provides their unity, e.g., to the water in the Atlantic Ocean.

Essence, *identity*, and *unity* are three basic notions in OntoClean that we have to consider when carrying out a foundational analysis of ontologies. There are two key points that need to be made at this stage. On the one hand, modelling experience shows that time-limited, anti-rigid properties often result from relationships with other entities or contexts, such as classifications that express a human association of a concept with an instance of a class. On the other hand, essence as defined by intensional properties is not to be intended as substance in the Aristotelian sense, but as the expression of an abstraction of attributes observed in *things* that is operated in the context of scientific disciplines in order to define *scientific objects*. We adopt here the epistemological analysis developed by Evandro Agazzi, which emphasises the difference between *things* in the world and *objects* in human and scientific discourse. Scientific objects are defined by predicates that result from operations by empirical sciences that identify "attributes (that is, properties, relations, and functions) that are present in things". These "structured sets of attributes" – the properties in OntoClean – allow the "clipping" of scientific objects out of things in the world, and this will happen according to the specific point of view of a scientific discipline.[13]

We need to be aware of this issue when analysing the formalised conceptualisations of classes and properties that make up an ontology, and that are supposed to represent "individuals, their attributes, and their relationships to other individuals", because this "representational vocabulary" is not about *things* as such, but it's much more an artefact defining "concepts, relationships, and other distinctions that are relevant for modelling a domain",[14] thus "clipping" the *objects* of a scientific discipline or domain of discourse out of the *things* in the world. This epistemological approach enables us to understand the limitations of ontologies for the sake of interoperability, because they result from a commitment to a specific domain of

discourse. At the same time, this epistemological analysis offers a robust methodol ogy for achieving transdisciplinarity in the definition of classes and properties in the general domain of HSS research: applying the OntoClean methodology, we will have to look for sufficiently generic and rigid properties to define common classes that can be generally accepted in the context of the field of different HSS scientific disciplines, while allowing the latter to develop subsequent specialisations, defining properties of the scientific objects specific to their field of discourse, as subproperties and extensions of the high-level ones. This is the goal of the SDHSS ontology ecosystem described below. On the basis of these foundational and epistemological principles, we can now explore the conceptualisation underlying the CIDOC CRM. To do this, we need to refer to the *Definition of the CIDOC Conceptual Reference Model* of the latest published version (7.1.2), produced by the CIDOC CRM Special Interest Group, which is the official version in form of a textual specification,[15] while serialisations in RDFS or OWL are available for production use. To explore the definition of classes and properties, i.e., their *intension* and to facilitate the navigation and exploration, the OntoME platform can also be used.[16] The introduction of the CIDOC CRM *Definition*, and in particular the part devoted to "Terminology" presents the foundational aspects of the ontology and shows that its conceptualisation is based on a methodology referring to notions similar to those defined by OntoClean: the definition of the *intension* of classes and properties can be found in their *scope notes*, the text defining their "traits", i.e., their properties in the sense of OntoClean. The provided labels and examples can help to understand the *intension* of the elements in the ontology, but it is the scope note that counts for their definition and notably the first sentence that provides their "basic identity" (*essence* in the wording of OntoClean) and expresses the criteria that should allow "informed people […] to agree that they refer to the same, single *thing* in its distinction from others, both in its extent and over its time of existence". The CIDOC CRM thus mainly focuses on the definition of intensional properties concerning *identity* of objects: "The notion of identity is key in the application of CIDOC CRM. The properties and relations it provides are designed to allow the accurate historical description of the evolution of real-world items through time". In contrast, the notions of *essence* and *rigidity* are not explicitly discussed. As for the *relational* properties in CIDOC CRM, the ones associating different classes, they "need not be part of the intension of their domains or ranges: such properties are optional", but inherited by all subclasses and descendants of the classes for which they are defined.

There is thus a tension between two different approaches to the definition of classes and properties, which partly explains some of the shortcomings of the ontology that we will encounter: some CIDOC CRM classes (namespace prefix *crm*), such as the *crm:E72 Legal Object* class, are created to add *relational* properties to all its descendant classes, here the ownership or other rights to which things are subject, expressed by the *crm:P105 right held by (→ crm:E39 Actor)* property, which will be inherited by the descendant classes. But the *intensional* property defining this class (the possibility of applying a right to a thing) is *anti-rigid* and thus, according to the OntoClean methodology, this class should not subsume the

crm:E18 Physical Thing class which is defined by a rigid property: "physical items with a relatively stable form". Admittedly, in the context of the object-oriented approach of CIDOC CRM, this logic is understandable and has its reasons, but the lack of a more in-depth analysis of the *essence* of classes, and their epistemological presuppositions, and notably of extrinsic time-limited properties like "being the subject of rights", that do not belong to the essence of objects, raises important issues.[17] As a matter of fact, the domain of discourse of the integration of museum databases is not the same as the one implied by the objective of "the exchange and integration of information from heterogeneous sources for the *reconstruction and interpretation of the past* at a human scale" (emphasis added), as stated in the *Definition* of the CIDOC CRM, because this is the whole domain of historical research, which creates specific objects according to the different scientific approaches of its subdomains. Therefore, the absence of a thorough analysis of the epistemological perspectives adopted in producing the CIDOC CRM, besides a reference to "material reality as whatever has substance that can be perceived with senses or instruments", which has a quite inductivist flavour, is far from sufficient to propose an ontology that aims at "integrating information based on material evidence available for *whatever human experience* [in commitment] to a unique material reality independent from the observer" (emphasis added). This situation prevents the CIDOC CRM from serving as a suitable basis for building a conceptualisation that integrates all the information produced in the field of contemporary HSS discourse. Indeed, the *crm:E72 Legal Object* class, providing the *crm:P104 is subject to (→crm:E30 Right)* property in order to express any "legal privileges concerning material and immaterial things" seem far away to be compatible with the complexity of information about, say, territories and their temporal evolution, be they cadastral parcels, administrative regions, or states.

Place as location

Despite these shortcomings, the conceptualisation of the CIDOC CRM with its clear influence from classical physics, provides several robust classes and properties, as well as very useful methodological and modelling approaches for representing physical phenomena in space and time, thus providing an excellent basis for the much-desired high-level transdisciplinary place ontology. This appears with evidence when it comes to defining the spatial properties of geographical places and their evolution in time. The class *crm:E53 Place* is defined as comprising "extents in the natural space we live in, in particular on the surface of the Earth, in the pure sense of physics: independent from temporal phenomena and matter" that serve to describe "the physical location of things or phenomena". This means that the essence of this class is to be a *location* in an abstract reference space but with no material substance. This is made even more clear in the scope note of the *crm:E27 Site* class, the only explicit class modelling a geographical place in the CIDOC CRM: "In contrast to the purely geometric notion of E53 Place, this class [crm:E27 Site] describes constellations of matter on the surface of the Earth or other celestial body, which can be represented by photographs, paintings and maps".

Even though it has no physical reality, an instance of the *crm:E53 Place* class inherits the relational properties of its parent class *crm:E1 Entity*. It thus can have one or more appellations (*crm:P1 is identified by* property) and can be qualified by one or more types (*crm:P2 has type*). A place/location in CIDOC CRM is identified by a *crm:E94 Space Primitive* (*crm:P168 place is defined by* property), i.e. a point, bounding box, or geometry provided in Geographical Information Systems (GIS). Although at first sight this class seems to correspond to the gazetteer's definition of a geographical place, in reality it is much more suited to the notion of a *location* than of a geographical place, since the latter, being a physical object with meaning, is much better described by the class *crm:E18 Physical Thing,* which includes physical objects that occupy a location in a reference system (property *crm:P156 occupies*) and provides a place intended as an abstract location with its situation in the physical space (property *crm:P157 is at rest relative to*).

In fact, the class that best corresponds to the notion of geographical place, intended as a part of the Earth's surface, with physical, observable, and measurable properties, and a specific meaning, is the class *crm:E26 Physical Feature*, the parent class of *crm:E27 Site*, defined as "identifiable features that are physically attached in an integral way to particular physical objects" and comprising "an area of property on the surface of the Earth [or] a landscape". In conclusion, the CIDOC CRM provides precise descriptions of the projection of physical things into an abstract space of *locations* but refrains from explicitly conceptualising the notion of geographical place intended as an entity in the material world.

This epistemological approach is even more visible in the class *crm:E92 Spacetime Volume* that was first developed in the *CRMgeo* extension and then added to *CRMbase* as a foundational class. It "comprises four-dimensional point sets (volumes) in physical spacetime [… that] may derive their identity from being the extent of a material phenomenon or from being the interpretation of an expression defining an extent in spacetime". The different properties of this class, and of its projection in physical space, precisely *crm:E53 Place*, express the relative position of different locations (containment, overlap, etc.) as well as their projection and relative position in conventional time expressed by the *crm:E52 Time-Span* class (*crm:P160 has temporal projection, crm:P132 spatiotemporally overlaps with*, etc.). The class *crm:E93 Presence* allows to model time-limited slices in locations, providing the projection of objects into different instances of *crm:E53 Place* for different, user-defined instances of *crm:E52 Time-Span*.

These classes and properties thus provide a thorough conceptualisation of the projection of physical phenomena into conventional space and their evolution in time. It should be emphasised, however, that their instances are not observable phenomena that can be photographed, but projections of these observable phenomena into an abstract physical space. The phenomena, the things in the world, are conceptualised in CIDOC CRM either in the form of physical objects, as we have indicated, or in the form of events occurring in time and space, with the class *crm:E4 Period* and its descendant classes. This class locates spatio-temporal phenomena both in conventional space (*crm:P7 took place at* → *crm:E53 Place*)

and in relation to physical entities that provide the reference context (*crm:P8 took place on or within → crm:E18 Physical Thing*). The CIDOC CRM also formulates some robust modelling principles concerning spatio-temporal phenomena, in particular the fuzziness of the contours of events, as well as of time-spans, the location in space always to be considered in its maximum extension, and the addition of refined Allen properties to the root class of temporal phenomena *crm:E2 Temporal Entity*.[18] This allows to express the relative position of temporal phenomena to each other (properties *crm:P173 starts before or with the end of*, etc.), independently from a projection in conventional time, i.e., without adding explicit time-spans.[19]

In addition to this rich conceptualisation of spatio-temporal phenomena in *CRMbase*, the *CRMgeo* extension also addresses the relevant issue of the different epistemic levels in information systems mentioned in the introduction of this chapter by distinguishing between "'phenomenal' and 'declarative' extents in space, time or spacetime in the real world (phenomenal) and the world described by information (declarative)". "Declarative Place (SP6) and Declarative Time Span (SP10) derive their identity from a human declaration" while the *CRMbase* classes Place (E53) and Time Span (E52) derive their identity from a phenomenon in the "real world" that "occupied or still occupies a unique Spacetime volume (E92)", but is always known with a certain degree of approximation.[20] This conceptualisation makes it possible to distinguish between mentions of facts in the documentation and historical sources, or even the representation of places using GIS geometries in information systems, that can be multiple and show differences between them, and the same features of the observed world that are described in the ontology. These phenomenal places, i.e., spatial locations, are represented and approximated by the respective declarative instances.

The epistemological and foundational analysis of the CIDOC CRM concept of place shows that, while its conceptualisation is capable of providing a precise and robust description of the location of physical objects and phenomena, understood as projection in a reference space, and evolution over time, it does not provide the tools to conceptualise geographical places in the rich social dimensions and representations that are constitutive of them from the perspective of HSS. This conclusion is perfectly illustrated by the definition of the property *crm:P74 has current or former residence*, which associates a social actor with a residence without further distinguishing between "the place where the actor [actually and physically] resides, or a legally registered address of any kind", whereas it is essential to be able to distinguish between a *de facto* residence and a legal residence, and to express their evolution over time. What's more, residence is associated with a simple location, an instance of the class *crm:E53 Place*, whereas in reality, as shown in the example of Queen Elizabeth's residence in Buckingham Palace provided in the CIDOC CRM *Definition*, the objects concerned by someone's residence are geographical places or buildings, i.e., physical objects, that as such have their own history and characteristics, and also time-limited, evolving projections in the abstract space. In the perspective of geographical sciences, summarised above, the *position* is captured by the CIDOC CRM, but not the *locale* nor the *sense* of places, and these

are the most relevant aspects of information concerning geographical places in the perspective of HSS.

DOLCE plus and SDHSS

To develop an ontology for integrating research information in these disciplines, the CIDOC CRM needs to be integrated into an ecosystem of extensions that builds on the robust aspects of its conceptualisation and add missing, relevant parts. This project, initiated by the Laboratoire de Recherche Historique Rhône-Alpes (LARHRA), is called Semantic Data for Humanities and Social Sciences (SDHSS.[21] It is based on a decade of experience in data modelling collected during the *symogih.org* project, "Modular system for the management of historical information", started at LARHRA in 2008 with the aim of interoperability and reuse of research data.[22] About 50 individual or collaborative projects and three successful PhD theses have used this collaborative virtual research environment based on a generic and open conceptual model, abstract enough to meet different research perspectives and designed to be extensible.[23] In the domain of geographical places, modelling experience was gathered concerning the evolution in time of buildings and notably bridges on the Rhône in Lyon, the evolution of French administrative districts (municipalities, cantons and *départements*), the transformations of forests in the French region of Avesnois,[24] and building a time-dynamic atlas of European states between 1815 and 1914, with a focus on the Belgian Revolution and the resulting territorial changes (1830–1839) and the unification of Italy (1848–1871). A methodology has been developed to integrate the information contained in ancient maps and other historical documents and produce rich information about the physical, social, and political development and struggles, as well as the geometries in a GIS representing the different types of places in their temporal evolution.[25]

Based on this experience, we adopted the foundational ontology *Descriptive Ontology for Linguistic and Cognitive Engineering* (DOLCE)[26] in order to have a sufficiently robust and proven framework to produce a sufficiently rich and generic conceptualisation in the new ontology ecosystem SDHSS. DOLCE is an ontology of particulars, i.e., it does not aim to identify the metaphysical substance of reality, but "to make explicit already existing conceptualisations through the use of categories whose structure is influenced by natural language, the structure of human cognition and social practices". This approach is particularly well-suited to the programme of creating an interoperable conceptualisation of information in HSS. Moreover, DOLCE has been complemented by the sister ontology Description and Situations D&S, developed in the same original project, whose domain is the foundational modelling of different perspectives of agents on the same events in the world.[27] The notion of *situation* is defined as an interpretation of events based on a particular conceptualisation, i.e. representations shared by agents and expressed by a description that assigns specific roles to the participants in the event. D&S was integrated with DOLCE to produce the *DOLCE Lite Plus* (DLP) ontology, which we use as a reference for our analytical work, and which was also reformulated and simplified in *DOLCE Ultra Light* (DUL), the base of the modelling approach of

Ontology Design Patterns.[28] If DLP provides an ontological basis for distinguishing between events in the world and their representations developed by different actors, this approach was extended by Aldo Gangemi in a paper that models the activity of scientific communities from a constructivist point of view and analyses the creation of scientific disciplines and their discourse.[29] We adopted this conceptualisation to develop the SDHSS ontology because it is consistent with the epistemology presented above, according to which scientific objects are classifications and definitions of properties about things in the world, developed in the domain of discourse of specific scientific disciplines.

DOLCE, which was developed using the OntoClean methodology, divides particulars, i.e., the entities to which scientific discourse refers, into four distinct and non-intersecting classes: endurants, perdurants, qualities, and abstracts. The essential difference between endurants and perdurants is their relationship with time: endurants retain their full identity over time, even as their properties evolve; perdurants, which evolve over time – and can be thought of as observable phenomena happening in time – are only partially present at any given moment, though identifiable as a whole. Endurants and perdurants are linked by the relation of *participation* of the former in the latter, for example the participation of people in a meeting or a battle. Endurants can be dependent and independent, because a hole in a shirt does not exist without the shirt, nor does a cave exist without the mountain (these are *features*), and the material that makes up a table (the wood, amount of matter) has an identity that is different from the one of the table itself, the latter resulting from its form (physical object).[30]

Two other classes, qualities and abstracts, provide a complete articulation of human discourse. *Qualities* are observable properties of endurants or perdurants, including occupied space as a property of physical objects, while temporality is a property specific to events. Note that in DOLCE qualities are conceived as *inherent* in objects: each chair has its own colour at a given moment. Each instance of the quality colour will therefore have its own value, i.e., it will occupy a point or "region" in a reference space, which is expressed by the notion of region as a subclass of the ontology's class *Abstracts*. The latter are entities which, having no temporal or spatial properties of their own, nor the status of qualities, are situated outside observable entities and, it may be added, appear to be the product of research community conventions – metric measures, for example – which allow property values to be located in a reference space.

In order to integrate the CIDOC CRM into an ontology based on the conceptual framework of DLP, we can now analyse the CIDOC CRM main classes in this perspective, then add new classes and properties in different namespaces of the SDHSS ecosystem (namespace prefixes *sdh* and *sdh-so*). The root class, *crm:E1 Entity*, contains all the objects in the CIDOC CRM domain of discourse. If we unfold the tree in OntoME,[31] we notice the two high-level classes *crm:E77 Persistent Item* and *crm:E2 Temporal Entity*, corresponding respectively, at least at first glance, to the classes *Endurant* and *Perdurant* of DOLCE. Missing are the classes *Quality* and *Abstract*, while there are four other high-level classes (*crm:E54 Dimension*, *crm:E53 Place*, *crm:E52 Time Span*, and *crm:E92 Spacetime Volume*).

These are, in the light of the DOLCE conceptualisation, *regions* and therefore subclasses of the class *Abstract* as they correspond to a particular position in a conventional reference space. They are therefore grouped in an extension's class *sdh:C5 Abstract Region* to emphasise this fact and avoid confusion. As we noted earlier, the class *crm:E53 Place* represents a location in an abstract space, not a physical place with social connotation.

The class *crm:E2 Temporal Entity* covers all the phenomena that take place in a limited period of time, with an explicit reference to the notion of *Perdurant* used by DOLCE. But in fact the root class of all spatio-temporal events is *crm:E4 Period* because, as we have seen, this class associates temporal phenomena with their location in physical space. And, more precisely, it's the *crm:E5 Event* class that provides *participation*, i.e., the properties that associate objects, endurants, with events (properties *crm:P11 had participant, crm:P12 occurred in the presence of*), and therefore correspond to the DOLCE *Perdurant* class, while *crm:E2 Temporal Entity* only provides the properties that locate phenomena in time, absolute, or relative. Let us also note that, despite having the same name, the essence of the *TemporalEntity* class of the *Time ontology*[32] is not the same as that of *crm:E2 Temporal Entity*, but that of the class *crm:E52 Time-Span*, because it actually expresses an abstract temporal region in the sense of DOLCE, whereas *crm:E2 Temporal Entity* represents a phenomenon that can be observed or photographed.

In the CIDOC CRM there is no equivalent to DOLCE's class *Quality* with the exception of *crm:E3 Condition State* whose instances describe "the prevailing physical condition of any material object or feature during a specific instance of E52 Time-Span". Apart from this exception, the CIDOC CRM applies the methodological choice not to model qualities of persistent items, but only the activity of observing them, as expressed in class *crm:E16 Measurement*, capturing the observed value using the class *crm:E54 Dimension* to represent a region in a quantitative abstract space defined by a unit of measure. It therefore seemed advisable to add to the SDHSS extension the class *sdh:C1 Entity Quality*, which corresponds to the DOLCE notion of a temporal quality and allows to add an essential component to the conceptualisation of research data in HSS. Indeed, it will be possible to deal with both qualitative and quantitative qualities of objects, and their evolution over time, in a different and complementary way to the events that structure the CIDOC CRM.

The class *sdh:C1 Entity Quality* is defined as a subclass of *crm:E2 Temporal Entity* because it has the same essence as the latter, it is an observable phenomenon limited in time, to which it adds the peculiarity of being a qualitative or quantitative property inseparable from the object it qualifies. Qualities of SDHSS are thus conceptualised as phenomena located in time but without direct reference to physical space and are situated on the same hierarchy level as the events of CIDOC CRM, corresponding to the perdurants of DOLCE.

sdh:C1 Entity Quality also provides the root of a foundational approach to mental and social life, which constitutes the bulk of the phenomena studied by the HSS. The CIDOC CRM limits its analysis of these phenomena to what is expressed in materiality: "What goes on in our minds or is produced by our minds is also

regarded as part of the material reality, as it becomes materially evident to other people at least by our utterances, behaviour and products".[33] Classes like *crm:E66 Formation* or *crm:E68 Dissolution*, which deal with the existence of groups, or *crm:E85 Joining* and *crm:E86 Leaving*, which express the relationships of actors with groups, are to be intended as a manifestation of social phenomena in "materiality", i.e., in observable spatio-temporal events. But in adopting this approach the CIDOC CRM precludes itself from modelling intentional reality as such. How can it then deal with the political roles of people, the legal domiciles of companies, the power of states over geographical areas, in a word: the complex properties of social objects that result from phenomena that exist only in the representations of people, and evolve in time and space, physical and intentional? The SDHSS extension introduces the class *sdh:C4 Intention* as a subclass of *sdh:C1 Entity Quality*, in order to integrate intentionality as envisaged by social philosophy as well as social psychology and sociology, based on the notion of mental *representations*, individual or collective.[34] This notion is conceptualised in accordance with a widespread understanding in these disciplines, formulated in a particularly precise way by the philosopher John Searle who observes that people, individually or in groups, pay attention to objects through their own representations.[35]

In the logic of the epistemological approach presented above, in order to ensure transdisciplinary interoperability, the conceptualisation of the class *sdh:C4 Intention* does not take a position in the philosophical or scientific explanation of this phenomenon, but confines itself to constructing a concept that captures a central aspect of the foundations of the social sphere, leaving it to the various scientific disciplines to define and explain it. Intentionality is conceived as a *quality* inherent to the mind of a person, or of several persons in collective intentionality, who mentally adhere to (shared) representations about objects. By interpreting and classifying the things of the world, intentionality constructs the objects of human (and scientific) discourse. It underlies social life and makes it possible to account for phenomena such as the attribution of roles to persons, the ownership of objects, the membership in groups, etc., the reality of which is not a quality inherent in the objects concerned (persons or things), but exists by virtue of a quality of the minds of the observers, which imparts to the things concerned an extrinsic classification. To put this in OntoClean terms, this is an *anti-rigid* property, like the fact that a thing is subject to a right in a given legal context.

This conceptualisation, inspired by DLP and its developments in a constructivist perspective, is based on the notion of *intentional collectives*[36] interpreted in the light of the epistemology presented above, and is in line with basic views in social philosophy and the social sciences. The class *sdh:C4 Intention* thus captures the information produced by the observation of intentional phenomena and becomes the root of the classes that describe social phenomena, acquiring a position equivalent to the class *crm:E5 Event*. The coherence between the intentional, on the one hand, and the material aspects of human and social life, on the other hand, is established by the property *sdh:P43 has setting*, which associates the mental, individual, or collective phenomena with their substratum located in the sphere of spatio-temporal events.

Two subclasses of *sdh:C4 Intention* express the two sides, static and dynamic, of intentional phenomena. On the one side, the *sdh:C7 Intentional State* class comprises opinions, beliefs, certainties, doubts, etc. of a person or collective of persons about representations concerning one or more objects. This class is further specialised by the *crm:C30 Connotation* class, which expresses the time-limited classification of entities with individually or socially defined types, and is the root of all classes expressing classifications, roles, legal connotations, etc. On the other side, the *sdh:C10 Intentional Event* class expresses the dynamic dimension of intentional phenomena, i.e., the changes of mind of persons or human collectives, or other dynamic phenomena taking place in the mind, such as reading or conversation, which are likely to bring about a change in intentional states. Its subclass *sdh:C46 Intentional Expression* includes manifestations of intentionality by means of speech acts, writings, actions, or activities. Representations about objects are expressed in order to communicate interpretations of reality, to give orders, to make social roles existing, etc. Raising a hand to vote involves two distinct events, both intentional and[37] It should be noted that intentional states and events do not have a direct projection in physical space, but they are present where their carriers, i.e., human beings, are located.

While the aforementioned classes provide a foundational approach to social life, further classes and properties describing more specific aspects are needed to fit the research agendas of different HSS disciplines. The *Social, Legal and Economic Life* SDHSS namespace (prefix: sdh-so) allows information about general aspects of social life to be expressed. This can be illustrated in relation to some of the issues raised above. The class *sdh-so:C27 Legal Fact* models the phenomenon that a persistent item is perceived by human groups, a whole society or parts of it, as having a legal quality over a given period of time. The *sdh-so:C17 Custom or Law* class collects sets of rules, intended here in a very general sense, that apply to a social group and its members, and that define the rights and duties of the actors involved, as well as the rights and liabilities regarding specific things, such as ownership. The *sdh-so:C27 Legal Fact* class thus expresses the same information content as the *crm:E30 Right* class, but without the need to introduce a *crm:E72 Legal Object* class into the persistent item taxonomy: it simply adds a social connotation, an *anti-rigid*, time-limited property to objects whose very essence is defined by their own *rigid* properties, in the sense of OntoClean.

Geographical places and their social and cultural context

Having presented this rich and articulated framework for modelling human and social life, we can now return to the question of conceptualising geographical places. Two disjoint classes represent places in the SDHSS ontology, *sdh:C13 Geographical Place* and *sdh:C17 Construction*: their definition is based on the modelling experience of the *symogih.org* project and the aforementioned foundational and epistemological analysis. If the *essence* of a building is more clearly identifiable as a basically immobile artefact built in view of human activity, that of a geographical place is more subtle. The rigid property that defines the essence of instances of the

class *sdh:C13 Geographical Place* is that of being a portion of the Earth's surface defined by human discourse. This is conformant with the intension of the parent class *crm:E26 Physical Feature* because according to the scope note its definition "coincides with the definition of 'fiat objects' (Smith & Varzi, 2000, pp. 401–420),[38] with the exception of aggregates of 'bona fide objects.'" This distinction was introduced to differentiate between boundaries that are somehow given in nature (*bona fide* objects) and those that are created by human cognition and convention (*fiat* objects). However, as has been observed in reference to the DOLCE ontology,[39] territories are social objects in any case and are therefore essentially *fiat* objects. In the same way, in the context of research in the HSS disciplines, geographical places are not to be considered as "things" but as scientific objects, defined according to the different domains of discourse that circumscribe the objects studied.

In order to define more precisely the nature of these objects, we can classify them using "kinds", that means generic types, in the sense of gazetteers, which must be *rigid*[40]: unique to an object and characterising it throughout its life. Kinds should be defined in a generic way to allow transdisciplinarity, while more specific types and classifications can be added by researchers to the same object. From the experience of several previous research projects, it appears that natural areas, settlements, legal or administrative areas (territories), infrastructure areas, etc. are generally usable kinds, but this should of course be discussed and agreed by the experts from different disciplines. To give an example, if we first observe a natural area with a few sparse houses and it then becomes a settlement, a place where a community of people live, we are defining two different instances of *sdh:C13 Geographical Place,* one of kind "natural area", the other of kind "settlement". If this settlement becomes or is included in a parish or in the territory of a municipality (two "territories" with different social meanings), we have four different geographical places even though they may be virtually situated at the same location, i.e., projected on the same instance of *crm:E53 Place*, and have the same or similar name, and partly coexist in time. These geographical places are not "things" but objects of (scientific) discourse, with specific properties, and can be classified and subsumed into three different kinds: natural area, settlement, and territory.

According to this conceptualisation, the *essence* of geographical places is defined as being physical features on the Earth's surface, delimited by human activity and social or disciplinary conventions. The *identity* of places can thus be further specified from the perspective of different scientific disciplines using transdisciplinary kinds and more specific classifications. The location of geographical places in the abstract reference space can be expressed using the CIDOC CRM conceptualisation, discussed above, namely the class *crm:E93 Presence* that allows to capture the evolution in time of the projection of geographical places on instances of *crm:E53 Place*. In the context of the SDHSS conceptualisation, *crm:E93 Presence* thus appears to be a time-limited quality of physical things, although it should be noted that temporal limits may be set arbitrarily by researchers, e.g., the extent of a settlement in a given century. According to *CRMgeo*, the locations that geographical places occupy are to be intended in the *phenomenal* sense (class *crm:E53 Place*) and can be

approximated (property *crmgeo:Q11 approximates*) by different geometries, derived from different sources, i.e., *declarative* locations (*crmgeo:SP6 Declarative Place*).

Regarding the names of places, and their evolution in time, they can be captured with the intentional class *sdh:C11 Appellation in a Language* that associates an object with a string that is considered as a valid identifier of the object in a specific linguistic and cultural context. In this way we can document the evolution of names over time and in different historical contexts. Various classifications or descriptions can be associated with a place, in particular with the class *sdh:C30 Connotation*, and more specific subclasses that capture the dimension of *sense* of geographical places for different groups of people as intended by geographers.

In terms of the complex social life that takes place in and around geographical places, it can be expressed using a rich set of instances of the classes *crm:E5 Event* or *sdh:C10 Intentional Event* and more specialised subclasses, while situations or claims of rights, prerogatives, and jurisdictions can be expressed using instances of *sdh-so:C27 Legal Fact* or *sdh:C48 Geographical Place Classification*. The same applies to instances of the class *sdh:C17 Construction* which allows to model fountains and statues, road infrastructure and bridges, and any kind of buildings or building complexes. Again, appropriate transdisciplinary kinds could help to define constructions as scientific objects common to different disciplines, leaving the latter to provide additional specialised classifications.

It should be noted that a bridge can be considered, according to different perspectives, as a geographical place, as the portion of the Earth's surface in relation to which human experience is situated, e.g., if it is seen as the place where a fight took place, before the struggle moved to the square on the other side of the river; or as a building if you are interested in the materials it was built with, or its intrinsic qualities, e.g., its length or equipment, and their evolution over time. Similarly, you can navigate an ocean, conceptualised as a geographical place and part of the Earth's surface, or dive into the amount of matter contained within the ocean's boundaries provided by the Earth's crust. These are two different *objects* of (scientific) discourse relating to the same *physical thing*.

Instances of the class *sdh:C23 Use,* a temporal entity, can hold information about different and complex functions of a building, from being used as a church, to being a stable, to being a church again, to being a disco after the secularisation of society. Of course, the same information can be expressed with a time-limited classification using specific types present in a controlled vocabulary, but in reality it is the activities associated with that building that are of primary interest. In both cases we are providing geographical places or constructions with extrinsic, anti-rigid properties. The evolution of the shape of the building (as distinct from its location in physical abstract space) or of the parts that make it up, and how they change over time, can be documented with appropriate temporal entity classes such as *crm:E79 Part Addition* or *sdh:C22 Physical Component* or *sdh:C42 Shape*.

SDHSS in action: Some examples by way of conclusion

The conceptualisation proposed in the SDHSS ontology ecosystem allows, on the one hand, to provide two disjoint classes, *sdh:C13 Geographical Place* and *sdh:C17 Construction*, whose essence is defined in a sufficiently generic and robust way to be adopted by different HSS disciplines to model geographical places as *objects* in a common domain of discourse. On the other hand, this conceptualisation enables the different disciplines to capture infinitely rich and complex aspects of human activity related to these objects, modelled according to their information needs and specific research agendas, but nevertheless based on high-level classes and properties that integrate those of CIDOC CRM and can be further specialised and extended in appropriate modules.

In the final, concluding part of the chapter, I would like to give some examples of how the proposed conceptualisation can address modelling issues with geo-historical research data that have been raised in the recent literature. The aim is not to propose a thorough discussion of these questions, but to illustrate how an appropriate semantic framework can make it possible to clarify essential aspects of the complexity of geographical places, what the semantic content of the available information is, and how it could be used to produce semantically rich, reusable research data.

The first question concerns the use of vocabularies and taxonomies of types to describe geographical places and their evolution in time, and in particular the alignment of type vocabularies used in different gazetteers. In the book chapter "Database of Topographic Objects 10k", Katarzyna Słomska-Przech and Wiesława Duży discuss the integration of different vocabularies of types regarding the classification of settlements, historical administrative units, and buildings. It should first be noted that type vocabularies relating to entities of a different nature are possibly not comparable at all: settlements and administrative territories belong to different kinds of geographical places, while buildings are physical constructions, not places, and thus belong to a different class. Clarifying first the *essence* of the objects under consideration, and then comparing the type vocabularies that classify them, would help to resolve some of the problems encountered.

Furthermore, it seems difficult to build an ontology intended to express the basic concepts and relationships in a domain, i.e., classes and properties (terminological sense), without applying a foundational analysis, as this is the only way to clarify the essential aspects of the domain being modelled. As we saw, a particular church is an instance of the class *sdh:C17 Construction* and one can certainly observe that it was built and used "for religious worship and religious activities" but "being a church" is an *anti-rigid* property and it wouldn't be suitable to create a "church" class because if this particular building becomes a disco, you'll then need to create a second instance representing it, belonging to another class and with a new identifier, although it's exactly the same building, albeit used differently. We can often observe that building types are used to identify the essence of these objects, when in fact they are types of use of buildings. The use may change, but the building's identity can be considered the same. This also applies to classifications such as

"market square", which is an area in a settlement used as a market but which could be used as a venue for concerts in later years, or a "higher education facility" which is a building used for educational purposes at one time and which could later be sold to a private company for offices. From the perspective of HSS research, type taxonomies and classifications cannot account for the rich and complex information that is available about the same objects and that is relevant according to different research agendas: this information should be represented by the *sdh:C23 Use* class or other classes that express social or spatio-temporal phenomena, relating them to the same instances of more generic classes with appropriate kinds.

How will it then be possible, however, to use this complex information to identify the same buildings or the same places mentioned in different sources or on different maps, with different names and types? Pawel Garbacz, Bogumił Szady, and Agnieszka Ławrynowicz have addressed the question of the identity of historical places in a very stimulating paper, which sets out a number of criteria for concluding that different sources refer to the same settlement.[41] The authors follow the OntoClean methodology and after stressing the difficult task of finding a "robust and non-trivial criterion of identity", and in particular, "diachronic criteria", they provide a foundational analysis of geographical places that are "construed as complex socio-physical entities, i.e., their name and type representing social aspects and the geographic location being the main physical aspect thereof", which is in line with the concept of geographical places proposed above, with all the rich physical and social features that characterise them.

Since these features evolve over time, appellations, locations in the reference space, types, unity (or merging into other localities) are conceptualised as "qualities" that are subject to "qualitative transformations". Criteria of identity can be defined, according to the authors, in observing the stability in time of at least a subset of the features: the appellation and the location, or the parthood and the appellation, etc. This robust and articulated analysis could also be expressed by adopting and enriching the temporal entity classes proposed in SDHSS, in particular the physical and social qualities, thus integrating this methodology in the context of the transdisciplinary approach proposed above. It should be noted that since geographical places are scientific objects, and not things, the final decision about the identity of settlements remains a choice of the researchers and cannot be decided just by rules or collections of features, but requires "reference to the domain knowledge", as it is well noted by the authors of the paper.

This methodology was applied by Vincent Ducatteeuw, with the necessary adaptations, to identify historical streets, squares, and bridges in the city of Ghent.[42] As the conceptual basis of the Urban Gazetteer of Ghent, Vincent Ducatteeuw adopts the location classes of CIDOC CRM, *crm:E93 Presence, crm:E52 Time-Span* and *crm:E53 Place,* in order to provide a model for the temporal evolution of urban places.[43] These "places" are expressed as instances of the class *crm:E92 Spacetime Volume*. The paper proposes an interesting approach, but at the same time it shows the difficulties of using the CIDOC CRM for modelling the historical evolution of geographical places, in particular because these are not explicitly modelled in the ontology, but only the notion of location in an abstract reference space (class

crm:E53 Place), which not only may lead to confusion, but also does not allow to take into account the complexity of the spatio-temporal and social evolution of geographical places. As the author points out, places have a physical reality, and it is indeed physical places and buildings depicted on old maps or contemporary photographs, not space-time volumes. The paper addresses this problem by adopting the notion of "declarative presence", inspired by CRMgeo, to capture the different representations of the same places and buildings in different sources: for each representation of an object in a map, an instance of the class *crm:E93 Presence* is added in the information system.

Unfortunately, this conceptualisation does not correspond to the intension of the CRMbase and CRMgeo classes. As we have seen, according to CIDOC CRM 7.1.2, a physical object (*crm:E18 Physical Thing*), which can be represented by paintings and photographs, defines instances of "E92 Spacetime Volume that constitutes the complete trajectory of its geometric extent through spacetime for the whole time of [its] existence" (property *crm:P196 defines*). For a given time-span, there is only one instance of the class *crm:E93 Presence* that associates the physical thing with its phenomenal location, a *crm:E53 Place*, which is the phenomenal (i.e., real) projection of the physical thing into the abstract geographical reference space. This phenomenal *location*, which cannot be directly observed in the past but existed as such, can only be approximated by selecting or integrating several different declarative locations (class *crmgeo:SP6 Declarative Place*), defined by geometries in a geographic information system created from old maps or other documents.

For the sake of interoperability and data reuse, it seems preferable to extend the CIDOC CRM and adopt a richer and more explicit semantics, more conformant to the intension of the CRM classes: buildings, as instances of the class *sdh:C17 Construction*, can be conceptualised as physical, human-made objects, e.g., Buckingham Palace. They are the setting of specific spatio-temporal and social events, or social situations, such as ownership, being the official residence of the king, etc., which can be described in a coherent way by other classes of the SDHSS ontology. Furthermore their qualities, such as shapes and new parts, can be documented, and their spatial presences projected to specific locations using in a conformant way the *crm:E93 Presence* class. The buildings can be identified by URIs, and linked to other authority files and public identifiers, while their locations, as instances of the class *crm:E53 Place,* are approximated by one or more geometries or geographic coordinates. Of course, the identification of these objects can be very challenging, as sources are not always complete and consistent,[44] and in some cases only an approximate representation of historical reality will be produced, but the adoption of a more elaborate conceptualisation is the prerequisite for the production of rich and consistent, interoperable, and reusable research data.

Finally, embedding the history of geographical places into the broader perspective of the SDHSS ontology ecosystem allows to address the issues raised in a review dedicated to challenges of historical gazetteers by Philipp Schneider, Jim Jones, Torsten Hiltmann, and Tomi Kauppinen.[45] We have already addressed the issues regarding the evolution of place names over time, using the intentional class

sdh:C11 Appellation in a Language, which captures appellations of objects at different times and in different linguistic contexts. And also the complex question of concepts that classify places, and a whole universe of representations around them: on the one hand, the class *sdh:C13 Geographical Place* is conceptualised as a portion of the Earth's surface defined by human discourse, it is therefore essentially *fiat* and defined by social representations; on the other hand, additional connotations, perspectives, narratives around places, historical, and contemporary, can be modelled with the class *sdh:C48 Geographical Place Classification* or other research-driven connotation classes.

The sphere of political and administrative power, and the intertwined and complex seigneurial and ecclesiastical jurisdictions and relationships, represent first and foremost intentional relationships between individuals and social groups. Geographical projection was then relevant but subordinate to power relations, and only gradually did territories emerge. Hierarchies are therefore above all interpersonal, multiple, and constantly evolving over time. They can be modelled using the *sdhso:C27 Legal Fact* or *sdh:C10 Intentional Event* classes, or new subclasses capable of describing more specific and complex situations. Since all these classes are subclasses of *crm:E2 Temporal Entity,* they inherit the refined Allen properties, which enable expressing relative situations in time (before, after, overlapping, etc.) without defining explicit time-spans. The temporal evolution of the spatial location of these phenomena can of course be captured by *crm:E93 Presence*, intended as a time-limited quality of physical things and spatio-temporal phenomena.

With regard to the provenance of information, it is important not to confuse the different epistemic levels of the discourse of the sources, that of the factoids, i.e., the mention of facts as they are read by the researchers in the sources, and that of the factual information derived from the former through the application of historical criticism, while adding alternatives to statements, as well as appropriate metadata to express uncertainty about the content of information. This process of factual information production is outside the scope of the CIDOC CRM and can be expressed using the Historical Context Ontology (HiCO),[46] an extension of PROV-O.[47] I will discuss this important but complex issue in another context.

In conclusion, if the CIDOC CRM, with its conceptualisation shaped by the epistemology of physics, allows the modelling of the localisation of phenomena, understood as projections in an abstract reference space, it must be integrated into a broader ecosystem of ontologies that allows the conceptualisation of the rich and complex information needed for research in HSS. With this aim in mind, the SDHSS ontology has been developed based on a foundational analysis of the CIDOC CRM using the OntoClean methodology and Dolce Lite Plus ontology, and on an epistemological analysis reflecting the constitution of scientific objects in different disciplines. It integrates a larger set of classes dedicated to the modelling of social phenomena intended as a high-level conceptualisation of intentionality in a perspective compatible with basic views in social sciences and philosophy.

The introduction of the classes *sdh:C13 Geographical Place* and *sdh:C17 Construction* makes it possible to explicitly identify the objects of (scientific) discourse commonly grouped under the term "place", as physical, human-made

objects, and to inscribe them into the rich semantic universe of spatio-temporal events and social relations modelled by the SDHSS ontology ecosystem. This does not mean that all the necessary classes and properties are already available, but that the methodology adopted lays the groundwork for collaboratively building, through interdisciplinary dialogue and refinement, an extensible and improvable ontology capable of representing geographical places from the perspective of different HSS disciplines, thus enhancing and promoting interoperability and reuse of research data.

Notes

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3 Naming the parts

Identifying key features within the urban landscapes of England and Wales circa 1900

Humphrey Southall and Paula Aucott

Introduction

The Historical Towns Atlas (hereafter "HTA") Project has mainly focused on mapping individual towns, with maps of each town from across the centuries as the most important sources. In recent years, creating atlases has increasingly meant building geographical information systems (GIS), which generally consist of layers each consisting of features of different types, such as roads and classes of building. Any urban historical GIS will therefore contain a *typology* of urban features tailored to the particular town, but as we seek to compare different towns and countries, and perhaps develop new theories of urban form, we need *ontologies* such as that provided by HOUSe (Historical Ontology of Urban Spaces), which define the fundamental components of towns in general, across different eras, countries, and languages.

While HOUSe's UrbanOnto and the layer definitions within a GIS are both explicit categorisations, every map contains some more or less implicit categories via its symbology, sometimes defined through a key and sometimes, especially in older maps and larger scale maps, simply as a set of conventions, specifying both what features are included and how they are represented. This chapter is a systematic exploration of what features are included on one particular very large set of maps, and how they are labelled: detailed maps of towns have always relied on replicating the actual arrangement of buildings and "thoroughfares", rather than relying much on symbologies. Here we use the generic term "thoroughfares" precisely because we will be exploring the precise usage of more specific terms like "road" and "street", as well as which particular buildings will be named on the map.

This chapter is concerned with systematically exploring the implicit ontology within the second edition of the Ordnance Survey's (OS) County Series 1:10,650 maps of Great Britain. This was the largest scale at which the whole country was mapped, covering all towns in Britain around the end of the nineteenth century. Which features within towns most needed to be identified by labels? How did this vary between different types of town and regions of the country? And what labels were actually used? This is therefore partly an analysis of selection decisions made by the late nineteenth and early twentieth-century surveyors working for Britain's national mapping agency, and partly an analysis of the naming decisions made by

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towns' builders and inhabitants.[1] The analysis presented here is based on a dataset containing well over a million geo-located text strings, so the main analysis is necessarily broad brush and statistical.

The next section describes the map series being analysed, the second edition of the OS County Series 1:10,650 mapping. The following section outlines the GB1900 "citizen science" project which organised over a thousand volunteers to extract all the textual information from the maps. Sections 4 and 5 describe the resulting dataset and present the results. Section 6 compares the GB1900 data with similar data from 1:2,500 scale mapping for a single city. The final section draws together the experiences of this project and how that reflects on the need for a standardisation in approach for exploring urban spaces as implemented by the HOUSe project.

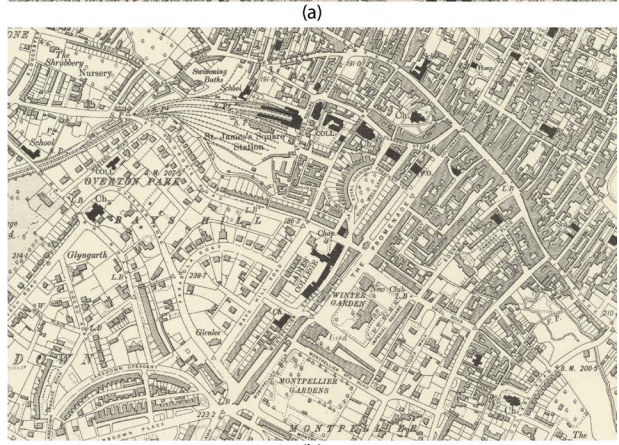
Ordnance Survey "six-inch" mapping

Although the Ordnance Survey was founded in 1791, initial mapping was at one-mile-to-one-inch scale, insufficient for recording property boundaries, or to provide significant detail within towns. From the 1840s a more accurate survey was carried out enabling publication at six-inches-to-one-mile scale (1:10,650). The first edition of this County Series was completed by the 1890s but employed a different prime meridian, effectively a slightly separate map projection, for each county, which means that digital scans cannot easily be assembled into a single mosaic. This problem was avoided in the second edition, published between 1888 and 1914, and it is that which forms the basis for the present research.[2]

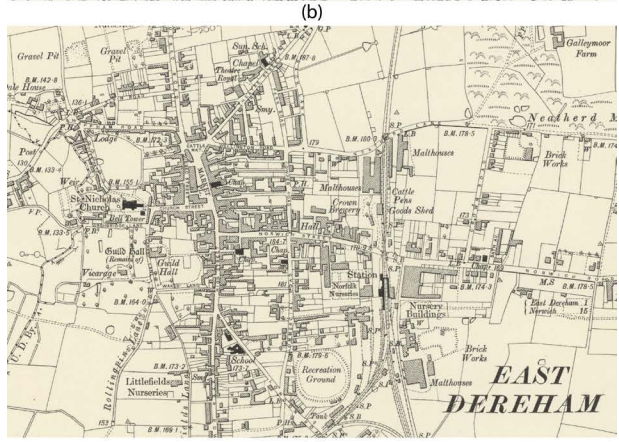
Figure 3.1 presents extracts from these maps covering three very different towns, and the reliance on labelling rather than symbology is obvious, because they contain no official symbology, and the sheets do not include keys. While the Ordnance Survey did produce a collection of working symbologies which developed over time, no stipulations were officially designated before map production began. Instead, these are large-scale plans, containing routeways, boundaries of areas including administrative units and fields, and the outlines of most buildings. Within towns, the major streets were named, but some of the smaller side streets and the multitude of back lanes were not. Although in rural areas every farm building and house was drawn separately, the majority of urban buildings were consolidated into blocks. Only the outlines of important buildings such as hospitals, churches, and schools were individually identified with a solid black fill compared to the diagonal thin black stripe ordinarily used for buildings. The more important urban buildings were also named, whichever kind of fill they had.

A simple visual comparison of the map view of some urban settlements offers an initial starting point of the character variation between different kinds of settlement. Centred on the town hall in Bolton, Figure 3.1(a) displays all the expected individual public buildings in a larger urban area, the infirmary, churches, schools, the railway station, market square, and the town hall. The more industrial nature of the town is highlighted by the factories on the left side of the map. They include a steel works, foundry, gas and electric works, and a mill, and there is even a goods station to facilitate the transport of the items produced. There is a concentration of

(a)



(b)



(c)

Figure 3.1 Extracts from Ordnance Survey second edition County Series six-inch map showing (a) central Bolton, (b) central Cheltenham, (c) central East Dereham.

Source: Reproduced with the permission of the National Library of Scotland.

terraced housing south of these industrial buildings offering housing for the large number of workers employed in these businesses.

By comparison, the streets of central Cheltenham in Figure 3.1(b) are wide, the properties well-spaced and plot sizes generous. The Town Hall was built shortly after this map was produced and is located just below the label for "New Club" in the Winter Garden area of the map. There are formal gardens visible and the famous Ladies College is prominently positioned, all of which indicates wealthier inhabitants. Perhaps more typical is Figure 3.1(c) depicting the small rural market town of East Dereham in Norfolk. Although the Guild Hall is close to the church, the other public buildings are spread out in different directions from the town centre and the small size of this settlement is emphasized by the fields clearly visible at the edge of the town.

The different aspects of these extracts emphasise the different kinds of urban settlements they represent. East Dereham has been a settlement since at least 1086 when it featured in the Domesday Book, but it has remained a small urban settlement.[3] In contrast Cheltenham was a Municipal Borough from 1885 and represents a medium-sized town while Bolton, the largest of these three examples, was originally also designated as a Municipal Borough, but its status was raised to a County Borough in 1889 as it expanded.

The GB1900 project

Britain has a long tradition of place-name research centring on the work of the Survey of English Place Names, commenced in 1922. The survey investigates the history of each place name, tracing them back to their earliest forms in medieval documents and employing expertise in Anglo-Saxon, Norse, and Celtic languages. However, the first stage of each county survey was the systematic extraction of place names from first-edition County Series six-inch maps, which are, among other things, arguably the first systematic survey of British place names.[4] Employing expert linguists to copy names from paper maps onto filing cards was time-consuming and helps explain why the Survey remains incomplete.

Starting in 2010, a consortium consisting of the Royal Commission on the Ancient and Historical Monuments of Wales, the National Library of Wales, the People's Collection Wales, and the University of Wales Centre for Advanced Welsh and Celtic Studies wished to create a similarly comprehensive survey of Welsh place names, but needed to move faster. Southall suggested that they still start with the six-inch maps, but use crowdsourcing and an existing geo-referenced digital mosaic of the maps to accelerate name extraction. This led to the Cymru1900Wales project, active in 2013 to 2014.[5]

That project was limited to Wales by its dependence on a commercially created mosaic of the maps which the Royal Commission had already licensed. However, the National Library of Scotland (NLS) had independently created a higher quality mosaic of the same map series covering the whole of Great Britain, so the later GB1900 project was possible at very low cost. In collaboration with the Welsh partners and NLS, researchers at the University of Portsmouth combined the Welsh software with the Scottish mosaic.[6]

GB1900 ran from September 2016 to January 2018. To reduce subjectivity, the volunteers were told to transcribe all text strings on the maps, rather than choose only those they thought were "place names". The first step was to locate a "pin", which would hold each transcription, at the bottom left of the first letter in the text string they were transcribing. Adding the pin created a co-ordinate for each transcription, and each pin had to then be confirmed by a second volunteer entering the same text string to be considered correct, acting as a quality control to improve the dataset. Nearly 1,200 people registered as volunteers for the project, many working long hours on these repetitive but somewhat addictive tasks.[7] Once the main transcription process was complete, several months were spent cleaning the data and finalising transcriptions which lacked confirmations. The resulting dataset was made freely available for wider public use under a Creative Commons licence from July 2018. It forms the basis for online gazetteers at the national libraries, as well as being used in academic research.[8]

The dataset

The main output from the GB1900 project is a dataset of 2,552,459 text strings, each linked to a point coordinate recording where it appeared on the maps. The present analysis is mainly limited to England and Wales, and we also excluded from the initial data selection ten very commonly occurring abbreviations, including "F. P." for footpath, "W" for well, and "P" for pump. This was done to speed calculation, but they would anyway have been removed later in the dataset preparation. Table 3.1 describes the initial dataset, containing over 1.3 million text strings. Defining "words" simply as strings of characters separated by spaces, most consist of between one and three words, with two being the most common.

Table 3.1 Numbers of text strings of different lengths, in numbers of words.

Number of words	*Frequency*
1	411,296
2	727,572
3	148,007
4	27,898
5	22,377
6	8,730
7	4,212
8	3,337
9	1,129
10	391
11	221
12	191
13	79
14	49
15+	109
Total	1,355,598

The reason for limiting the analysis to England and Wales is that the system of local government there provides a very simple way to divide the data up by type of community, which does not exist for Scotland. Under the 1894 Local Government Act, most of England and Wales was divided into four types of district: Rural Districts, covering farming villages but also many areas dominated by mining; Urban Districts, for small towns; Municipal Boroughs for medium-sized towns; and County Boroughs for the largest cities. London was outside this system and mainly consisted of Metropolitan Boroughs, with the central City of London having the unique status of County Corporate. The next stage of the data preparation was to assign each text string to a particular local government district based on its coordinate, using the digital boundaries the Great Britain Historical GIS Project had created to map the 1911 census. The type of district was then copied across from an existing transcription of a 1911 census table. To enable simple mapping, the name and identifier for the Administrative County containing the district was also added.

Our concern in this chapter is not with individual places or features, but with types of feature, and these are best studied by analysing the individual words within strings: there were many, many different names for thoroughfares, but they almost always include "ROAD", "STREET", or similar terms. A new dataset was therefore created consisting of the individual words from within the 1.3 m. strings, which initially contained 2,664,889 words. Note that the analysis is currently limited to the first 20 words in all strings, but the very small number of strings with more words are mainly detailed descriptions of archaeological discoveries. As well as each word, and the local government district and county it was located in, the new dataset also includes the position of the word within the string and the full text of the string it comes from.

Next, all punctuation and brackets were removed from the words, and then many "words" were flagged to be excluded from the analysis for not being words at all (all single character words, usually parts of initials, and "&C", an abbreviation for *et ceteris*), or for being very common while not indicating a type of feature (specifically, the words "BY", "OF", "NEW", "OLD", "THE", "NORTH", "SOUTH", "EAST", and "WEST"), or for being parts of labels for administrative boundaries, posts, or stones (which includes all words from strings which end with "BY."). A special case was "ST", which at the end of a string usually means "Street" but at the start of a string is usually an abbreviation for "Saint": all "ST"s which were the first word in their string were excluded.

Finally, a number of common abbreviations were expanded: "PL" became "PLACE", "RD" became "ROAD", "ST" became "STREET", "CHAP" became "CHAPEL", "CH" became "CHURCH", "SCH" became "SCHOOL" (and "SCHS" became "SCHOOLS"), and "STA" became "STATION". As will be seen in the next section, this has a substantial impact on our results. After the above exclusions, the final dataset includes 2,200,307 words.

Analysis

Table 3.2 presents the most important results, listing for each type of area the most frequently appearing words. Unsurprisingly, the commonest terms for Rural

Table 3.2 The 25 most frequently occurring words within feature labels for each type of local government district in England and Wales c. 1900 (the words highlighted in grey usually identify roads/streets).

Rural Districts		*Small towns (Urban Districts)*		*Medium towns (Municipal Boroughs)*		*Large towns (County Boroughs)*		*London (Met. Boroughs and the City)*	
Word	*Freq.*	*Word*	*Freq.*	*Word*	*Freq.*	*Word*	*Freq.*	*Word*	*Freq.*
Farm	58,035	Road	10,165	Street	6,864	Street	19,115	Road	3,318
Spring	39,376	Street	8,297	Road	5,677	Road	10,309	Street	2,075
Wood	34,482	Lane	6,592	Lane	1,917	Lane	2,639	Church	824
Quarry	30,666	Farm	5,351	School	1,674	Church	2,368	School	797
Lane	30,645	House	5,321	Church	1,653	School	2,113	Chapel	569
House	29,043	Chapel	3,837	House	1,566	Chapel	1,663	Park	261
Pit	22,168	Quarry	3,818	Farm	1,553	Works	1,604	Station	254
Hill	22,124	Hill	3,575	Chapel	1,419	House	1,544	Place	211
Plantation	16,455	School	3,572	Mill	1,266	Farm	1,408	Hill	168
Ford	16,294	Church	3,111	Works	1,174	Hill	1,301	Grove	154
Church	16,149	Works	3,091	Hill	1,134	Lodge	1,103	Square	151
Lodge	15,679	Wood	2,981	Lodge	1,090	Park	1,091	Lane	151
Chapel	14,479	Spring	2,957	Quarry	974	Mill	1,023	Gardens	146
Mill	14,103	Lodge	2,821	Spring	925	Station	878	House	138
School	13,495	Shaft	2,768	Wood	829	Hall	873	Schools	118
Stone	12,929	Mill	2,617	Station	750	Place	860	Lodge	113
Cottage	12,662	Pit	2,284	Park	736	Spring	689	Works	108
Bridge	12,351	Hall	2,131	Pit	705	Ground	652	Avenue	102
Hall	11,468	Station	2,077	Bridge	685	Pit	624	Hall	87
Road	9,229	Bridge	1,840	Stone	667	Bridge	621	Dock	78
Copse	8,952	Reservoir	1,722	Hall	643	Quarry	613	Terrace	71
Gravel	8,050	Cottage	1,686	Cottage	631	Avenue	611	Bridge	70
Shaft	8,000	Stone	1,618	Reservoir	484	Grove	537	Wharf	65
Park	7,564	Park	1,515	Ground	417	Shaft	502	Nursery	58
Chalk	7,501	Coal	1,479	Weir	389	Terrace	499	Crescent	57

Districts are distinctively rural, “Farm”, “Spring”, and “Wood”, while the commonest terms in urban areas all indicate thoroughfares: “Road”, “Street”, and “Lane”. The Oxford English Dictionary[9] defines these respectively as “a path or way between different places”, “a road in a city, town, or village, typically comparatively wide”, and “a narrow way between hedges or banks; a narrow road or

street between houses or walls". Our results confirm that "Street" is distinctively urban, while "Lane" is far more common than "Road" in rural areas. "Street" is markedly more common than "Road" in larger towns, except for London, where there are over 50 per cent more "Roads" than "Streets". It is interesting to note here that Słomska-Przech and Lilley struggled with classifying the thoroughfares identified on their example maps, as the UrbanOnto ontology lacked sufficient detail.[10] Looking back at Figure 3.1 in (a), the central part of Bolton is mostly "Streets", but with two "Roads" heading away from the central area and three "Gate" names, indicating a probably earlier association with entry to the town. In comparison (c) East Dereham has a number of "Lanes", mostly to the west of the town centre as the settlement merges with the countryside.

The commonest types of buildings referenced in London and other large towns are churches, chapels, and schools, followed by industrial sites identified as "Works". Rural features such as "Farm" and "Wood" are surprisingly common in urban areas, but note that many "urban" administrative units would have contained substantial undeveloped areas, and perhaps especially so where we are combining maps from the 1890s with boundaries from 1911. One problem with the highly aggregate approach taken here is that many words could indicate specific types of rural feature, such as "Hill", "Grove", and "Park", but also often appear as parts of urban street names.

Table 3.3 examines pairs of words within strings, with single letter words and certain other terms unrelated to urban form manually excluded. The frequencies here are much lower than in Table 3.2 and it is harder to draw conclusions. Many pairs appear to be parts of longer strings, often street names. For example, three of the four commonest pairs for London are "Park Road", "St Johns", and "Hill Road"; as it happens, this chapter is being written in part of London, in or very close to "Kidbrooke Park Road", "St Johns Park", and "Shooters Hill Road". Outside London, terms related to extractive industries dominate: "Old Quarry", "Old Shaft", and "Gravel Pit". Distinctively urban features are harder to find, but "High Street" appears in all lists, and "Gas Works" appears in three. It is surprising that "Cricket Ground" appears in all four lists while "Football Ground" appears, lower, only in one.

Table 3.4 investigates industrial activity, listing the commonest words that appear in strings which end in "Factory", "Mill", or "Works". The last is much the most common, and the number of brick works is remarkable: in this period, most towns were built from bricks made locally as appears in the bottom right corner of the Dereham map extract. Factories seem focussed on food or clothing production. Mills are rather different: only the smallest operations, sawmills and corn mills, were labelled by what they made, most others being named as businesses, with "Victoria Mill" and "Albion Mill" being particularly common. In Bolton, for example, "Borough Mills" is named in the top left corner of the map.

Figures 3.2 and 3.3 explore geographical distributions. In each map, numbers of words were counted for each urban local government district, but then to make the results more visible they were aggregated by the administrative county each district formed part of; the areas of most counties were

Table 3.3 Most commonly occurring word pairings, by type of local government district (terms relating to administrative boundaries, flooding, and tides have been removed).

Small towns (Urban Districts)		*Medium towns (Municipal Boroughs)*		*Large towns (County Boroughs)*		*London (Met. Boroughs and the City)*	
Pair	*Freq*	*Pair*	*Freq*	*Pair*	*Freq*	*Pair*	*Freq*
Old Quarry	1,879	Old Quarry	483	Brick Works	314	Park Road	53
Old Shaft	1,130	Site Of	306	Old Quarry	261	High Street	35
Old Coal	1,073	Brick Works	204	Old Coal	247	St Johns	32
Air Shaft	800	Gravel Pit	202	Park Road	213	Hill Road	19
Meth Chapel	712	Gas Works	189	Cricket Ground	211	Town Hall	18
Gravel Pit	650	High Street	177	Recreation Ground	207	Dry Dock	17
Brick Works	608	Old Shaft	169	Old Shaft	202	St Jamess	17
Coal Level	469	Old Shaft	169	Air Shaft	141	Cricket Ground	16
Gas Works	469	Cricket Ground	156	Mort Chapel	139	James Street	15
Water Works	439	Water Works	136	Gravel Pit	135	Mort Chapel	14
Old Quarries	406	Park Road	131	Towing Path	128	King Street	13
Site Of	404	Chalk Pit	127	Sun School	115	John Street	13
High Street	382	Meth Chapel	127	Football Ground	114	Queens Road	13
Towing Path	357	Clay Pit	123	Sand Pit	112	Hill Station	12
Old Shafts	348	Sand Pit	120	Coal Shafts	111	Recreation Ground	12
Sand Pit	344	Recreation Ground	114	St Johns	111	Goods Station	12
Cricket Ground	310	Mort Chapel	112	Clay Pit	110	Gravel Pit	12
Coal Shaft	308	St Marys	112	Gas Works	107	Water Works	12
Clay Pit	302	St Johns	105	Meth Chapel	107	Victoria Road	12
Old Gravel	280	Remains Of	103	High Street	107	George Street	11

mostly Rural Districts, but their data is excluded here. This does mean that for the more rural counties a large area is shaded but the data come from only a small part. Firstly, Figure 3.2 plots the percentage of all religious buildings that were labelled as chapel rather than church. Although historically a chapel could mean simply a Christian place of worship which was small and without a permanent priest, in nineteenth- and twentieth-century England and Wales

Table 3.4 Words most often preceding words indicating industrial premises (urban local government districts only; the words highlighted in grey appear not to indicate type of product).

Factory		*Mill*		*Works*	
Word	*Freq.*	*Word*	*Freq.*	*Word*	*Freq.*
Boot	21	Saw	189	Brick	1295
Shoe	21	Corn	146	Gas	707
Woollen	13	Cotton	41	Iron	282
Lace	7	Paper	26	Tile	227
Clothing	5	Victoria	25	Chemical	153
Bacon	4	Flour	24	Dye	126
Shirt	4	Lower	24	Water	121
Matting	4	Vale	21	Engineering	90
Fustian	3	Albion	19	Bleach	74
Cheese	3	Bank	18	Sewage	72
Brush	3	Spring	16	Steel	59
Fireworks	3	Upper	16	Glass	45
Hosiery	3	Bridge	15	Manure	40
Biscuit	3	Silk	15	Cement	39
Silk	3	Hill	14	Fire	39
Royal	2	Clough	13	Victoria	39
Milk	2	Albert	12	Rope	39
Mineral	2	Hall	12	Lime	37
Leather	2	Wood	12	Print	37
Arms	2	Holme	12	Wagon	37
Margarine	2	Park	12	Hill	34
Glove	2	Low	11	Lane	34
Chemical	2	Grove	11	Engine	33
Hat	2	Street	11	Salt	33
Blanket	2	Lane	9	Electric	32

it more usually indicates a non-conformist place of worship, churches being Church of England or Roman Catholic. This map broadly confirms what we know from the only other systematic source we have for the geography of religion in nineteenth-century Britain, the 1851 Census of Religious Observance:[11]

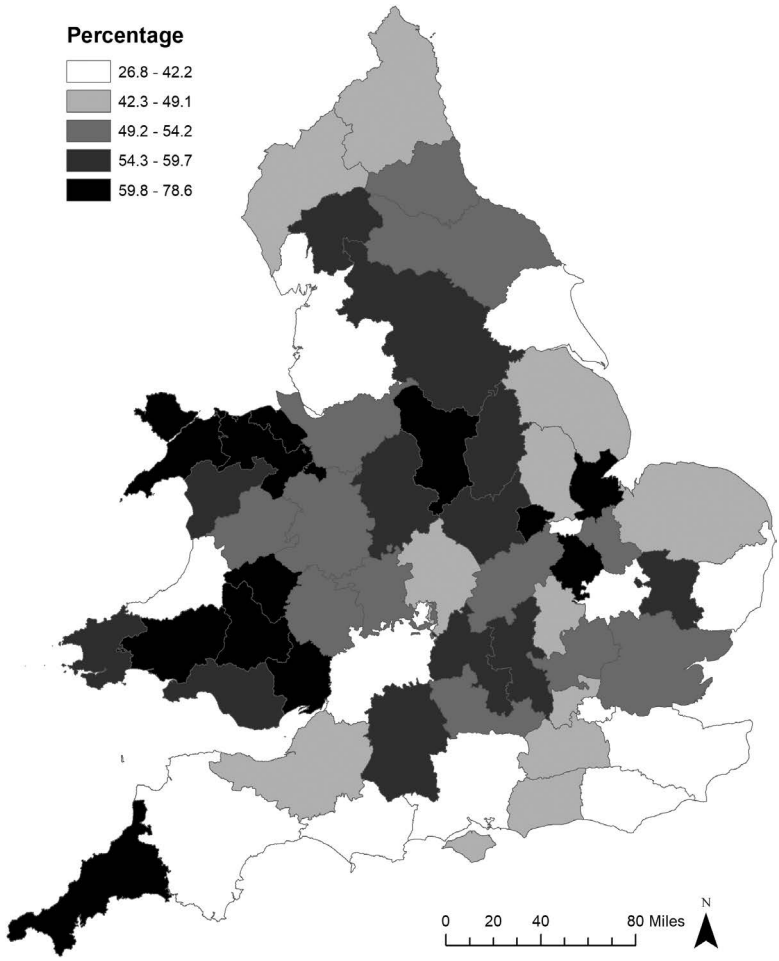


Figure 3.2 "Chapel" as percentage of names for religious buildings in GB1900 (urban local government districts only).

non-conformists, especially Methodists and Baptists, were concentrated into Wales, Cornwall, and parts of northern England.

Figure 3.3 investigates a different aspect of built form, examining the names of thoroughfares and focussing in particular on words which indicate a degree of grandeur: Avenues, Crescents, and Squares. The results do suggest some concentration of grander designs into the southeast, although small numbers probably give misleading results on the Welsh border. One such outlier is Cheltenham, as seen in Figure 3.1(b), with a "Royal Crescent", "The Promenade", and "Imperial Square" alongside thoroughfares named "Colonnade", "Regent Street" and other "Places", and "Squares" in the central area. These grandly named routes are wide and have large building plots for a central location, reflecting their local status.

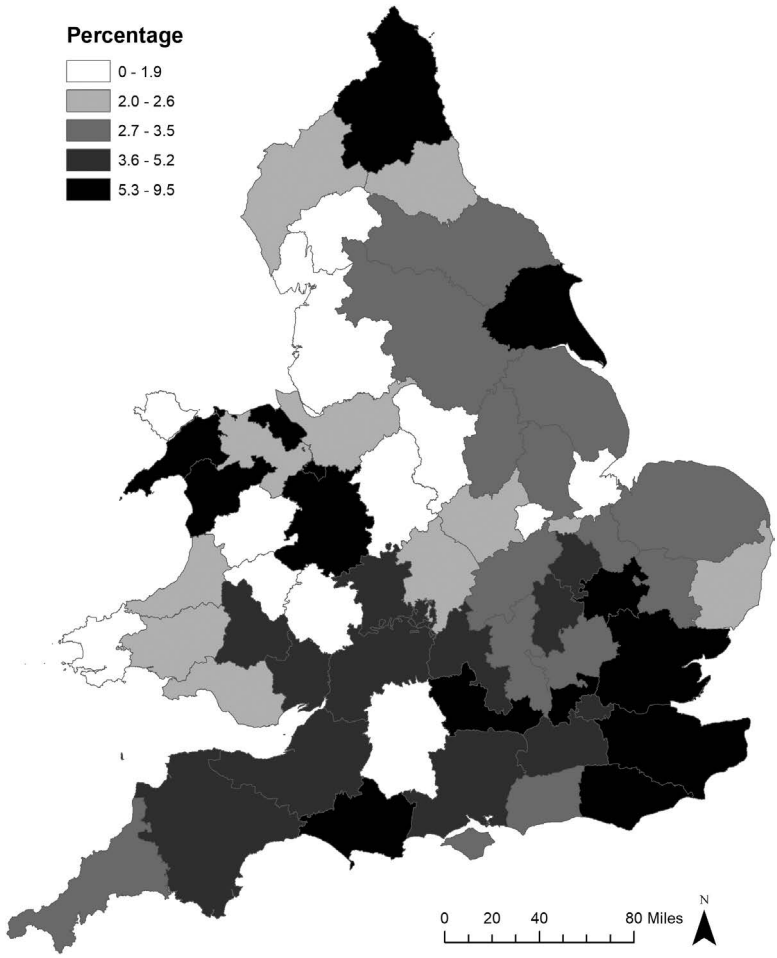


Figure 3.3 "Avenue", "Crescent", and "Square" as percentage of names for routeways (urban local government districts only; "routeways" also include "Lane", "Road", and "Street").

An alternative mapping that included "Terrace" would give a very different result, emphasising northern England, so despite London's Nash terraces this word clearly lacked grandeur.

Finally, Figure 3.4 is a first attempt to use the data to investigate the internal layout of towns, although it is not entirely successful. It is based on first searching the whole dataset for strings ending in "Town Hall" or "Guildhall", and then finding the nearest string containing "Market" within the same local government district. We noted, in the earlier discussion of three examples of town maps, that Cheltenham was mapped slightly before the construction of its town hall. Bolton has a very prominent town hall at its centre, with a marketplace marked just to the

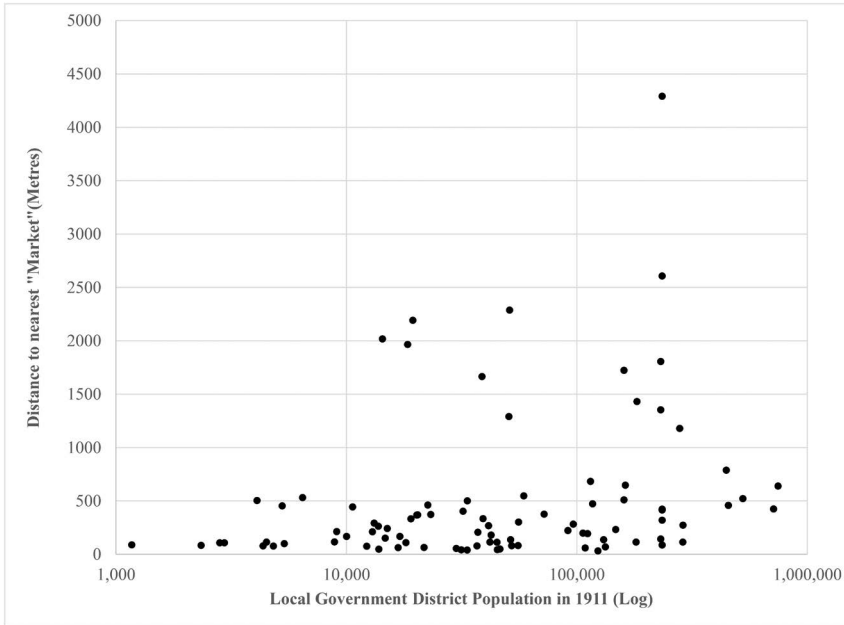


Figure 3.4 Distance between town halls and markets, relative to population size, for 90 Towns in England and Wales.

north and a "Wholesale market" area just to the south. Dereham also has a central Guild Hall and on the other side of the route to the church is a thoroughfare called "Market Place" with an area called "Cattle market" at one end, although there is no market building.

It is therefore perhaps unsurprising that we could identify only 90 town hall/market pairings in the data. Figure 3.4 plots the distance between town hall and market against the total population of each district, as reported by the 1911 census, and shows that in most cases the market was within 500 metres of the town hall, with the exceptions entirely in the larger towns. Another analysis located a total of 254 town halls or guildhalls within the England and Wales data and identified simply the nearest feature that was not a street name, but the results were inconclusive.

Comparison with 1:1,250 scale mapping

While the County Series six-inch maps were the most detailed to cover the whole country, the Ordnance Survey also mapped settled and farmed rural areas at 1:2,500 scale, some towns at 1:500 scale and, eventually, all towns at 1:1,250 scale. This chapter is based on the six-inch mapping because a national mosaic had already been constructed, by the National Library of Scotland, and the textual content had then been systematically extracted, by a project whose central purpose was to

create a comprehensive national gazetteer, mountains and moorlands included. It would clearly be preferable for a study of towns to use larger scale mapping, and the chapter here by Słomska-Przech and Lilley discusses working with the 1:2,500 mapping and UrbanOnto.[12]

Fortunately, a directly equivalent dataset has been created from the 1:2,500 mapping, albeit limited to the city of Edinburgh, in Scotland. In May and June 2022, NLS together with the Alan Turing Institute ran a crowdsourcing project to transcribe names from the 25-inch-to-the-mile maps covering the city of Edinburgh. Volunteers drew an on-screen box around individual words appearing on the map, then transcribed a single word inside it. Each word had its own box, but where it should form part of a group, for example "Post Office" or "Sunday School", a function allowed them to be flagged as a group and put in order. The volunteer then added a tag to categorise the type of feature being transcribed, distinguishing areas, streets, buildings, natural and other features. The quality control phase included a manual tidy-up of the transcriptions, including merging together as a single entry all individual words flagged as part of a group.[13]

A visual inspection of this "25-inch" dataset, using QGIS, showed that it covered an area extending slightly beyond the boundaries of the City of Edinburgh and the adjacent port town of Leith, as recorded in a boundary dataset constructed by the Great Britain Historical GIS to map the 1881 census. It has already been noted that the historical digital boundaries for Scotland are more problematic than those of England and Wales, but in this case, they are being used only to ensure that data extracted from the national GB1900 dataset cover exactly the same area as the 25-inch data. The raw 25-inch data were simplified to points, then processed in a similar way to the GB1900 data, to exclude boundary markers and so on. This created a dataset of 8,118 words extracted from within the transcribed strings, while the Edinburgh and Leith GB1900 data similarly contained 3,524 words.

Table 3.5 lists the 25 most common words in each of the Edinburgh datasets, and can be compared with Table 3.2. No very striking conclusions can be drawn. It confirms that the 25-inch mapping provides a more comprehensive listing of streets than GB1900, and the higher frequency of "Lodge" and "House" suggests that more individual buildings are named. Conversely, the number of "Stations" is very similar. The much higher ranking of "Place" in both types of mapping as compared to Table 3.2 appears to be a feature of specifically Scottish mapping; it could label either a thoroughfare or a particularly grand house.

The Edinburgh 25-inch data were created through manual crowdsourcing, in a very similar way to GB1900, but the project was a component within the Turing Institute's larger "Machines Reading Maps" project, whose aim is to replace manual transcription by automated methods, aiming to "read map content at scale using tools for text, not images" and then "integrate place entity linking and image annotation tools to make text on maps meaningful, i.e., automate the linking of individual transcriptions to a more abstract ontology".[14] The potential implications of this project are discussed in the conclusions.

Table 3.5 The 25 most frequently occurring words within feature labels appearing on six-inch and 25-inch maps of Edinburgh and Leith.

OS 25 inch		*OS 6 inch (GB1900)*	
Word	*Freq.*	*Word*	*Freq.*
Street	401	Street	179
Place	217	Road	113
Church	199	House	78
Lodge	191	Lodge	68
Road	164	Place	68
House	132	Church	66
Terrace	132	Station	52
School	119	Quarry	51
Bank	95	Park	48
Park	86	School	44
Lane	86	Crescent	41
Works	81	Terrace	40
Sluice	77	Edinburgh	33
Quarry	74	Works	28
Edinburgh	73	Burn	28
Station	66	Water	26
Hall	59	Hill	25
Crescent	58	Spring	25
Well	57	Mains	24
Mill	54	Leith	22
Stone	50	Gardens	21
Ground	48	Cottage	19
Hotel	45	Mill	18
Spring	45	Granton	18
Sheepfold	44	Bank	18

Conclusions

The exploratory nature of this chapter cannot be over-emphasised: it demonstrates a new way of looking at historical towns not individually but en masse, using what is currently an almost unique dataset; as far as we know, the only direct comparison is with the Edinburgh 25-inch data, and that is limited to one city, and was created by one of the GB1900 partners. While the data and methods are novel, the significance of these particular findings is limited. That said, there are benefits to quantifying what is qualitatively obvious, such as the different usages of the various words for thoroughfares: commonly "Street", "Road", and "Lane"; in the more upmarket parts of southern England, "Avenue", "Crescent" and "Square"; in Edinburgh, "Place". Once we begin comparing different classes of town, the results start to go beyond the obvious, and this would arguably be even more true if we could also make comparisons over time.

Clearly, this approach is an alternative to the UrbanOnto approach adopted by the HOUSe project as explained by others in this volume.[15] Instead of taking a modern dataset and using experts to extend the information to incorporate historical elements and features, this chapter explores the information provided within a historical source itself, and offers an alternative starting point for categorising urban features. One more or less philosophical question is how far we are analysing the naming decisions made by the inhabitants of each town, and how far are we analysing the decisions of mapmakers about what to include. This is arguably just as much an issue with the more traditional construction of town atlases by extracting and synthesising information from old maps. We would argue this is less of a problem in a comparative analysis of different towns using maps created by a single national mapping agency, as with the GB1900 data and potentially with the OS 25-inch mapping.

The data used here were created by a team of over a thousand volunteers, in a project with a very different central goal. However, the previous section introduced the "Machines Reading Maps" project which potentially seeks to remove the need for armies of volunteers and may enable the much wider application of methods for bulk textual analysis of maps, and so the more systematic analysis of urban history through town maps. Until a working example of this automated method is successfully constructed, the reliance on volunteers must continue. Our results clearly reflect the priorities specified by the Ordnance Survey to its surveyors, but the variety of feature names used also hints at the diversity of local selection.

Notes

1 For further discussion of the representation of landscapes through maps, see: Øyvind Eide "Modelling as a bridge between maps, spatial concepts, and the territory" (pp. 9–20), and for discussion of changes in those landscapes over time, see: Katarzyna Słomska-Przech, Marta Demchyna, and Tomasz Panecki "Changes in spatial development of Lviv from the second half of eighteenth century to the present day" (pp. 182–211), both in this volume.

2 Richard Oliver, *The Ordnance Survey in the Nineteenth Century: Maps, Money and the Growth of Government.* (Charles Close Society, 2014); Kasra Hosseini et al., "Maps of a Nation? The Digitized Ordnance Survey for New Historical Research," *Journal of Victorian Culture* 26, no. 2 (2021): pp. 284–299, https://doi.org/10.1093/jvcult/vcab009
3 Norfolk County Council, "Norfolk Heritage Explorer: Norfolk Historic Environment Record: Parish Summaries [Website]," 2017, https://www.heritage.norfolk.gov.uk/record-details?TNF210-Parish-Summary-Dereham-(Parish-Summary); Anna Powell-Smith and J Palmer, "Open Domesday [Website]," 2010, https://opendomesday.org/place/TF9813/east-dereham/
4 J Brian Harley, "Place-Names on the Early Ordnance Survey Maps of England and Wales," *The Cartographic Journal* 8, no. 2 (1971): pp. 91–104.
5 Paul S Ell, Lorna Hughes, and Humphrey Southall, "Digitally Exposing the Place Names of England and Wales," in *Placing Names*, ed. Merrick Lex Berman, Ruth Mostern, and Humphrey R Southall, Enriching and Integrating Gazetteers (Bloomington: Indiana University Press, 2016), pp. 146–162.
6 Humphrey Southall et al., "GB1900: Engaging the Public in Very Large Scale Gazetteer Construction from the Ordnance Survey 'County Series' 1:10,560 Mapping of Great Britain," *Journal of Map & Geography Libraries* 13, no. 1 (January 2, 2017): pp. 7–28, https://doi.org/10.1080/15420353.2017.1307305
7 Paula Aucott, Humphrey Southall, and Carol Ekinsmyth, "Citizen Science through Old Maps: Volunteer Motivations in the GB1900 Gazetteer-Building Project," *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 52 (February 11, 2019): pp. 1–14, https://doi.org/10.1080/01615440.2018.1559779
8 Paula Aucott and Humphrey Southall, "Locating Past Places in Britain: Creating and Evaluating the GB1900 Gazetteer," *International Journal of Humanities and Arts Computing* 13, no. 1–2 (2019): pp. 69–94, https://doi.org/10.3366/ijhac.2019.0232; Mariona Coll Ardanuy et al., "Resolving Places, Past and Present: Toponym Resolution in Historical British Newspapers Using Multiple Resources," in *GIR'19: Proceedings of the 13th Workshop on Geographic Information Retrieval* (New York, USA: Association for Computing Machinery, 2019), pp. 1–6, https://doi.org/10.1145/3371140.3371143; Tian Lan and Paul Longley, "Geo-Referencing and Mapping 1901 Census Addresses for England and Wales," *ISPRS International Journal of Geo-Information* 8, no. 8 (2019): pp. 320, https://doi.org/10.3390/ijgi8080320
9 "Oxford English Dictionary," Oxford English Dictionary, 2022, https://www.oed.com
10 See: Katarzyna Słomska-Przech and Keith Lilley, "Cartography and the city: Exploring urban ontologies through historic town-maps," in this volume, (pp. 153–181).
11 Paul S Ell and Terry R Slater, "The Religious Census of 1851: A Computer-Mapped Survey of the Church of England," *Journal of Historical Geography* 20, no. 1 (1994): pp. 44–61, https://doi.org/10.1006/jhge.1994.1005
12 Słomska-Przech & Lilley, (pp. 153–181).
13 National Library of Scotland, "Ordnance Survey 25 Inch Edinburgh Transcriptions: Project Information Page. [Website]," 2022, https://maps.nls.uk/transcriptions/edinburgh/viewer/information/#workflow
14 Alan Turing Institute, "Machines Reading Maps: Creating a Generalisable Machine Learning Pipeline to Process Text on Maps and Catalysing Humanities, Scientific, and Cultural Heritage Communities to Use Map Text as Data. [Website].," Alan Turing Institute Website, 2023, https://www.turing.ac.uk/research/research-projects/machines-reading-maps
15 Elsewhere in this volume can be found considerations of the elements affecting the development of the HOUSe ontology. For discussion of toponymical uncertainties over time, see: Grigori Chlesberg, "How names transform space: The change of street names in Poznań and Gdynia in the nineteenth and twentieth centuries" (pp. 84–99); for spatial, toponymical, functional and temporal uncertainties, see: Anna-Lena Schumacher, Michał Słomski and Daniel Stracke "Uncertain information and spatial

objects. Examples from works on the HOUSe project and the European Historic Towns Atlas series" (pp. 100–129); and for identification uncertainties, see: Katarzyna Słomska-Przech and Wiesława Duży "Database of Topographic Objects 10k as the basis of the Historical Ontology of Urban Space ontology – construction, verification, validation" (pp. 133–152).

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Part II

Investigating urban space

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4 Narrating Szczecin

Creation of urban authenticity through touristic city trails

Tabitha Redepenning

Introduction

When do we start to perceive the city not as an accumulation of buildings but as a sphere of social interactions with a past, present, and future? This chapter analyses the strengthening of narratorial elements in city walks and the way how urban space representation changes.[1]

Thanks to a guidebook, a visitor supposedly knows a city even before setting foot in it. Guidebooks are created to give orientation in an unfamiliar place by listing the most important institutions, streets, sights, landmarks, administrative buildings, etc. Nevertheless, presenting only monuments leads to a failure to tell the reality of urban space. It does not answer the questions posed when actually experiencing a new place and its daily life.[2] This summarises one of the central dilemmas of guidebooks: finding the balance between putting the "sights"[3] in focus, while also capturing the multifaceted aspects of urban space.

By its nature, the process of guidebook creation is selective and calls for simplification and generalisation. Guidebook creation is therefore influenceable on several levels. Firstly, by what the authors perceive to be attractive and informational for tourists, partly reciprocating their feedback. Secondly, by the aspects of the city which the authors personally aim to highlight. Next, guidebooks are shaped by what the materiality of the city (built heritage) provides as a starting point, and lastly – as Barthes points out – by what the underlying implications are about a given place, and which aspects in the representation of a city "go without saying."[4] This might be influenced by common practices and underlying implications about tourism, but it can also be shaped by historical connotations of a place. This chapter aims to dissect the elements that "go without saying" by analysing guidebooks of the city of Szczecin[5] over the course of 70 years.

This chapter analyses how the city of Szczecin is represented in guidebooks from the beginning of the twentieth century until the 1980s. It covers the question of how city space representation evolves over time. The focus lies on how tourists are supposed to perceive city space through the lens of a guidebook. As Barthes pointed out, the guidebook text and visuals already pre-shape and reinforce consumers' understanding of what they are about to see.[6] It is, therefore, an analysis of the representation of urban spatial understanding and feeds into the complex grasp of the city as a whole. Guidebook authors are seen as local actors with a specific

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way of representing city space. The analysis provides insight into how local actors link the past and present to urban space.

Tourist guidebooks play an essential role in different areas of research, which were identified by Peel and Sørensen.[7] Since the late 1980s, research, especially on guidebooks, has been put in the spotlight, with John Towner advertising for them as a primary source for the historical research in the touristic field.[8] For their texts and images, the books play an essential part in analysing the "tourist gaze."[9] Franklin has criticised this, e.g., since the visual focus puts tourist sights in a passive role while neglecting the active creation of meaning in the social process around tourist activities.[10] Additionally, Peel and Sørensen point out that tourists do not necessarily perform their activities according to the script (hence the guidebook), which is often overlooked by researchers.[11] The other research field covers the guidebook's function as a mediator for tourism practice and the tourist's usage of guidebooks. Guidebooks are seen as objects through which meaning is constructed, contested, and circulated.[12] It is important to note that travel guidebooks are not uncontested by the users, e.g., by the (anti-)tourism discourse[13] and the wish to "look behind the curtain."[14] Hence, this analysis will not analyse the tourist gaze or perception of the city, but solely focus on the representation by the local actors as an expression of their version of the city's identity and active construction of self-understanding and meaning.

While guidebook analyses had already been performed for the most famous Western tourist destinations and the most popular guidebook publishers at the beginning of commercial tourism (e.g., Thomas Cook, Karl Baedeker, and John Murray), local guidebook publishers are seldomly in focus as urban actors. As a city with a history of being in the periphery of nations and not a primary tourist destination, Szczecin developed a unique way of attracting tourists. While, naturally, historical events play an important part in Szczecin's development, it is important to note that the analysis does not examine the city's history itself, as has been done by such authors as Labuda, Wachowiak, Białecki, Piskorski, Hackmann, or Silski.[15] While the *censura* of World War II with the war destructions, exchange of population and introduction of entirely new local actors is recognised, this analysis focuses on the continuities overarching the turbulent years of the war and afterwards – going beyond the re-coding of the city after 1945, as was done by Musekamp.[16] It reveals broader trends not bound to national connotations of "German" or "Polish." This chapter analyses 15 German pre-1945 guidebooks and 15 Polish guidebooks on Szczecin issued after World War II. Local guidebook publishers were selected to underline the grass-roots approach to tourism with on-site knowledge and the expression of local actors' perspectives on Szczecin. This criterion excludes publications of German expellees organised in official or semi-official groups after World War II and the *Vertriebenenverbände*.[17]

Tourism development in Szczecin

In 1873 the fortifications of Szczecin were dismantled (Figure 4.1). Before, Szczecin was mainly seen as a transit station to reach the desired spa resorts at the Baltic Sea and summer retreats ("*Sommerfrische*") by steamship.[18]

The fast industrialisation and expansion of the town fuelled an enormous economic boom after dismantling the fortifications. Prestigious building sites, like the representative district north of the former fortifications and the alleys, greenery, and housings towards the northwest, became attractions for tourists.[19] The analysis, therefore, starts with the guidebooks from 1901 until 1911 by *Hermann Saran,* a local guidebook publisher.

The tourism economy in Szczecin became professionalised with the founding of the *Stettiner Verkehrsverein* in 1907. The analysis includes their guidebooks for the period of 1912–1939. Selecting those two publishers enabled analysing a relatively constant stream of publications during the period of German administration in Szczecin. The pavilion of Stettiner Verkehrsverein was located at a leading traffic junction in the town: close to the Berliner Tor (today: *Brama Portowa*). It underlines this actor's ambitions to become the central information point for tourists. Stettiner Verkehrsverein publications also reflect the city's economic problems triggered by the outbreak of World War I[20] e. g., an advertising book ("*Werbebuch*") to attract investors in the economically difficult interwar period. Only in the late 1920s, the situation for tourism in Germany stabilised, and a drastic increase compared to pre-war times was recorded. Most of the wealthy middle class participated in travelling and package tours, but a broader public could also participate. In Szczecin, the Stettiner Verkehrsverein started to publish flyers which had a much shorter description of Szczecin highlights.[21] It was a form of professionalisation, as well as a fast response to the increasing demand driven by tourists. Nevertheless, the 1929 economic crisis led, on the one hand, to the closure of hotels, but on the other, to the emergence of "wild" travel agencies competing with established institutions.[22] After 1933, German tourism changed drastically. The fascist regime under Hitler replaced the national tourist agencies with the National Society of German Travel Agencies. Membership was voluntary at first, but became mandatory with the establishment of the *Reichsverkehrsgruppe Hilfsgewerbe des Verkehrs* (*RHV*), which controlled – as part of the Economic Ministry – the whole travel industry. At the same time, it was also required to be part of the Reich Committee for Tourism, which belonged to the Ministry of Propaganda and, therefore, was under the control of Joseph Goebbels and Hermann Esser.[23] Regardless of the significant interventions and transformations of the tourism sector organisation, the regime still aimed to provide a certain degree of tourist "normality" to serve their political aspirations better.[24] Showcasing a "normality" – outside of obvious political connotations, which were subversively antisemitic and discriminative – indirectly supported the regime's power, but benefitted local tourism agencies.[25] In Szczecin, the Stettiner Verkehrsverein succumbed to demands and supported Hitler from an early stage.[26] While Germany's attack on Poland at the beginning of World War II did not affect tourism severely at first, the increasing losses and bomb raids on the German side led to a temporary suspension of tourism in Szczecin in the 1940s. By the end of the war, the most severe bomb raids had left huge parts of Szczecin's inner city, the harbour, industry, and northern residential districts in ruins.[27]

When Szczecin found itself under Polish administration after World War II, tourism was one of the centrally planned industries in the emerging state structures. Nevertheless, political and economic crises had a considerable impact throughout

the existence of the PRL (Polish People's Republic) on touristic activities. In Szczecin, tourism was again politically influenced. To provide an example, the *PTK* (later *PTTK*) guidebook points out the "invaluable cultural advantages"[28] in setting up tourist infrastructure quickly – an annotation even more important regarding integrating the new territory into the "mainland." Tourism became a tool to present industrial and economic accomplishments, educate the locals and other Poles (foreign tourists not until much later) in a cultural and politically desired sense, and foster the Polish nationalisation in Szczecin after the border shifts. One of the main figures of this process was *Czesław Piskorski*[29] and the local office of the Polish Tourist and Sightseeing Society *PTK/PTTK (Polish Sightseeing Society/ Polish Tourist and Sightseeing Society)*.[30] Both actors are deeply intertwined since Piskorski was one of the founders of the local PTK branch in Szczecin, and his materials were highly influential on the tourist sector. They were used during PTK/PTTK's training to become a licensed tourist guide and were a reference for their tours.[31] Both actors are at the intersection of national directives from the Ministry of Communications, which was in charge of tourism in post-war Poland and was represented by regional actors like the Voivodeship's Tourism Committee (Piskorski became Chairman in 1955), and the grass-root work of local guides on the city premises. Moreover, the PTK was one of the organisations to which the Ministry of Communications handed over formerly secured touristic facilities after World War II.[32]

The PTTK regularly published their conducted tours, which give an overview of their impact and difficulties.[33] Comparing it to the demand and supply analysis of tourism development in similar industrial cities, like it has been done for Poznań, Łódź, Lublin, and Gdańsk from 1947 to 2017 by Zmyślony and Nowacki,[34] the numbers show a similar development with six turning points until the 1990s. In the post-war period, tourism was mainly domestic and organised in groups, e.g., school and day trips.[35] In Szczecin, the number of PTTK guides was comparatively low, but slowly growing (about 900 guided tours and under 50,000 overall attendees per year). The political crisis with the end of Stalinism in 1956 resulted in a decline of guided tours, and reached a historical low at the end of the 1950s. Even though West Germans could technically travel to Poland, organised tours only started to become popular in the middle of the 1950s. German tourists often wanting to visit their former houses and living places[36] exerted only a marginal impact on the guided tours in Szczecin. Nevertheless, the adaption of the urban lifestyle and population shift into urban areas in the 1960s led to growing demand for tourist activities. Additionally, the authorities changed their approach and now used tourism as an instrument for social policy. This led to investments and the emergence of planning cycles for tourism. By the end of the 1960s, tourism was incorporated into the national planning system. For the PTTK in Szczecin, this meant a peak of guided tours and attendees at the end of the 1960s, with only a short-term drop in 1968, when the student protests occurred. Part of it was the new influx of Swedish and Danish tourists.[37] While the protests of December 1970 had no visible effect on tourism activities in Szczecin, the border opening towards the GDR and the recognition of the Oder–Neisse line as the border by West Germany led to a temporal increase in PTTK-guided tours and tourist influx peaking in 1975. As Zmyślony and Nowacki analysed for the other

cities, the partial opening of the market and joint ventures with international hotel chains, as well as the pro-spending approach of the Polish government in the tourism sector, led to the consistent growth in demand and supply in the tourism sector. The demand was controlled and subsidised, often focussed on youth tourism, low-price hostels, social tourism for state companies, and workers' usage of vacation homes.[38] The economic crises and protests in 1976 marked the beginning of a decrease in the PTTK tourist activities in Szczecin, dropping to the lowest number since the 1960s in 1982 with the introduction of martial law (1981–1983). Afterwards, the PTTK tourism activities in Szczecin never quite recovered, with a steady decrease since 1986; the downward trend was enforced by the loss of the referendum in 1987 and the reduction of centralised state power. After the political and economic crisis in the 1980s and the political turn in 1989, PTTK continued to diminish in its activity in Szczecin until today. In contrast, tourism in Poland, in general, continued to grow with privatisation, a free market economy, and the liberalisation of foreign trade.

Guidebooks: Maps, books, or time travel?

Since this analysis focuses on the space representation in guidebooks, it examined the conceptualisation of guidebooks: the appearance and order of street indexes, maps, explanatory texts (like on the town's history or specific monuments), and suggested city walks. It is examined how the city walks were designed (e.g., according to districts, themes, history) and which city premises they cover. The comparison reveals the selective process, the respective focal points, and the different strategies to capture the city's complexity in a limited medium.

The analysis of the concept behind Hermann Saran guidebooks and their table of contents revealed two different types of guidebooks. Type I has a clear focus on the map with a short booklet listing the points of interest.[39] Type II has a more significant focus on descriptions and explanations, includes a chapter on history, the importance of Szczecin, and city walks.[40] Its structure repeats in editions from around 1908 and 1911.[41]

What distinguishes the two types is how information is represented. In type I guidebooks, the points of interest are enumerated in lists and marked on city maps as an accumulation of dots. These points share similar functions, e.g., there is a separate list with all the churches, one for all the museums, etc. In this sense, they work as an extension of the map's legend. Type II already connects these dots in a descriptive city trail and offers a different way of experiencing the city through a linear narrative. Nevertheless, it still includes huge parts, which solely list points of interest, just like in type I guidebooks.

In 1912, the Stettiner Verkehrsverein followed Hermann Saran's example of the narratorly guidebooks, but included additional chapters which single out one specific city object e.g., the Hakenterrasse, due to its recent completion and representative function. They are also further distinguished from type I since the points of interest are not solely named in lists, but accompanied by a few sentences of description. With the guidebook from 1912, the Verkehrsverein applies marketing strategies by starting with an introductory short description of the city, information

about the organisation, and the most important monuments of Szczecin on the first two pages,[42] instead of providing readers first with a street index. This strategy aims to gain the reader's interest before getting into more detail about the city. In the 1920 publication, more literal elements were included, e.g., a fictional dialogue about the beauty of Szczecin written by Cemetery Director Georg Hannig.[43] This development continues in the following edition.[44] It shows the tendency to deviate further from simply naming the information and towards increasingly more literal and narratorly features. The guidebook becomes a narrative of a town in which the single elements of the city become connected.

The production of flyers in the 1920s and 1930s by Stettiner Verkehrsverein enforces this development drastically. No listings and not even a map were included. On the one hand, they were used for tram or bus roundtrips, so no map was needed since the route was already given. Nevertheless, the reader navigates the city only by the descriptive texts, which are diverse and focused, e.g., on the development of the city[45] or on the sights a visitor could see in only one day or a limited period.[46] Besides, the flyers posed a cheaper alternative to extended guidebooks, but are also a sign of the increasing professionalisation due to the increasing demand and tourism influx.

The 1935 guidebook changed in style and form – a sign of the changing approach to tourism by the National Socialist – using a square format instead of a vertical and a bright multicoloured cover. Most of the chapters describe a thematic city walk: either focussing on one particular area (e.g., the Old Town, the Bulwark, the harbour) or highlighting one particular aspect of the city: "young/green" and "modern residential town." The other chapters list all buildings serving one specific function (churches, restaurants, etc.), but each building is described in a few sentences.

While the publications of the Stettiner Verkehrsverein present a mix of listings and literal elements, there is the tendency to focus increasingly on the narratorly representation of Szczecin. Single buildings are even more highlighted with lengthy descriptions. Moreover, there is the growing presence of city walks. Their structuring of the city space is dominated by the proximity of buildings, combining sights close to each other in one city walk. Nevertheless, the former medieval city walls which also determined the area of the fortification, play an important role. Even though they are not visible anymore, the city walks are conceptualised along the "mental" districts of Old Town (within the former walls) and New Town (outside of the former walls), not overstepping from one part to the other.

After World War II and when Szczecin fell under Polish administration, the PTK published a guidebook already in 1946. The main difference between these early publications is the focus on the Piast origin of Szczecin and the allegedly Piast-related monuments, e.g., with chapters on "About the Piast Past"[47] or invitations such as: "Go to Szczecin, get to know the Piast monuments."[48] This illustrated how nation-building narratives permeate into everyday areas such as tourism. The focal point of this narrative was the castle,[49] which was proportionally described in much more detail in the city walks than other monuments or even singled out with its own walking tour.[50]

Regarding the structure of guidebooks, already in 1948, Piskorski established a fixed one which determined the following editions until 1968.[51] In those editions,

there were no listings of buildings. The guidebooks were structured by city walks, similar to the German guidebooks. Neighbouring sights were clustered in one city walk, but the mental division into Old Town, New Town, and harbour remained (Figure 4.2). The continuity of the 1920s and 1930s in German guidebooks and the early Polish guidebooks shows how urban space representation prevails.

Nevertheless, there were other novelties in the Polish guidebooks, e.g., the 6-Years-Plan city walk, which was meant to present the development plans that the PZPR (Polish United Workers' Party) had for Szczecin.[52] Since, during this time, the leading target group of tourists to Szczecin were other Poles, it was essential to show the town's economic relevance and development. On the other hand, it shows an interest in trying out new forms of city guidance – paving a new way through the city, independent of the narrative of the Piasts or the "traditional" district division. Nevertheless, the trail only appeared in this edition.

More sustainable was the city walk established in 1960, leading "from the train station to the harbour."[53] It also appeared in the following editions. Since the train station was the main arrival point for tourists – especially adolescents and students – and the harbour economy was the town's main focus, the introduction of this walk shows once again how Piskorski used tourism to promote economic and political goals, and adjust them to the target group. Additionally, the direction of the city walks, overruling the historically grown districts (Old and New Town) and going from South to North, aligns with this period's geographical north-to-south city expansion. It was an urban development applied to Szczecin after World War II using the Odra River and the newly constructed "Odra Artery" (1947–1949), a road along the Odra River, as a primary means of transport to connect industry in the north to the city centre. As Bernhardt and Musekamp pointed out, the German administration in the 1930s had similar plans already, which could not be executed due to the density of buildings along the Odra River (which were erased by the bomb raids during World War II).[54] Nevertheless, the city planning and construction of main streets for transports only was visible in the touristic guidebook ten years later. On the other hand, the trail was the condensed version of the three other established city trails and, therefore, an offer for tourists who wanted to dedicate a smaller amount of time to the city routes. The diversification may also be a reflection of the increasing demand of tourist offers in the 1960s.

In this period, we thus see the disappearance of sight lists in the analysed guidebooks. Listings are replaced with more extended literal texts on the city and the usage of city walks to connect monuments. Moreover, there is a continuity from the German period in the design of the city walks, which aligns with the historically grown districts. Nevertheless, the exceptions show that this sectioning was not absolute, and Szczecin's space representation started changing.

In 1974, the city walk design shifted again, and a different way of representing the city was established. Still, there were the "traditional" city walks of Old Town and harbour, but the focus shifted from clustering objects by their proximity towards highlighting the timely origin. While the "Old Town" city trail continues to refer to the part of the town within the former fortifications, the "New Town" city trail shifted towards the north-western part and was renamed as "city centre,"

but still referred to the historically grown district. It covered the residential and prestigious area constructed after the fortifications were dismantled. The harbour continues to describe the district north of the Chrobry Embankment with the industrial structures. The difference is that these three trails, therefore, stand for three different time layers of the urban development of Szczecin: up until 1873 within the medieval city walls and later the fortifications, the city expansion after 1873, and the harbour as a timeless element of the town.

With the newly added trail on "The castle and its environs," an additional time layer is supposedly tangible for the tourists. It shows the part of the town on the hill where the remnants of the first eighth-century settlement were discovered and where the Pomeranian Dukes constructed their fortifications. The discovery of settlement remnants under the castle was part of a broader ongoing archaeological research project called "Millennium" since the 1950s.[55] It was constructed as another proof of the Slavic origin of the town and employed to underline the narrative of the "recovered territories."

The "Podzamcze" trail, however, is to show the time layer of the medieval town. Here, the focus lies on a small fragment of the former city wall, St. John's Church, a bridge, the Old Town Hall, the Loitz Bank, several residential houses, and the Bastion of the Maiden with the Seven Cloaks. Many elements of this walk hail from the fifteenth century or earlier. Nevertheless, the guidebook points out the many reconstructed or newly built objects which stand in the same place as their former medieval "counterparts."

The Chrobry Embankment played a more significant role than in the former guidebooks, as a trail was named after it. Hence, the path covers another district which developed around 1900, after the dismantling of the fortifications, and was (together with the mentioned north-western part of the town) one element of the representative district created in the booming period before World War I. It had a special role since the former fortification (Fort Leopold) was the last one to be dismantled and the building plans were highly discussed for several years.

Dividing the city into six instead of three city trails enables more detailed explanations of single objects and ensures each trail's walkability. Keeping in mind the selective process of city walk design, it is visible how Piskorski picked monuments not only to highlight the historical importance of the monument itself, but also clustered them to ensure that the whole area covered by *one* city walk becomes–in his eyes–the representative of *one* significant time layer of the city development. To put it bluntly, the city walks count as evidence of the urban history, showcasing a "journey through time" in each district. This form of travel, not just horizontally across the city space but also vertically across the different stages of (town) development, resembles what Hasso Spode describes as romantic time travel. It was the dominant form of travel by the bourgeoisie in the eighteenth century to escape industrialisation and making sense of new places. This was done by not only looking at the monuments/sights, but also by understanding the steps of human development to which they referred.[56] The guidebooks by Piskorski not only offered such a travel to the pre-industrial times of the eighth century and medieval times, but also included other significant stages of city development. Therefore,

the city's urban expansion was not only described in written form in the general introductions of the books or recognisable on one specific building. It was visible and–more importantly–tangible by walking through the districts. This strategy ensured a stronger focus on the formerly supposedly invisible stages of city development, such as the first settlement and the Middle Ages.

Conclusions

The analysis shows three overall developments in the guidebooks. In the early years of the twentieth century, the first type resembled an extended version of the map legend. The sights were listed and summarised according to their functionality with little to no explanation. The buildings were presented as single points of interest in the city space. Narrative elements were scarce. The second type already used city walks, combining the different sights into a linear narrative and paving a way through the density of the inner city. The walks were conceptualised according to the historically grown districts of Szczecin. This development continues until after World War II, when the first type of guidebook increasingly distinguished itself from the second type. The guidebooks diverge further from the plain listings of buildings and include more literal and narratorial elements. The representation of the city space is increasingly influenced by the division that the guidebooks suggest via the city walks, continuing with space representation similar to the pre-war German guidebooks. Nevertheless, there are exceptions: they became shorter or featured a specific event. The most distinguishable transformation occurred in the 1970s, when Piskorski established new city walks, moving away from the established division of the town. The city walks pose a form of time travel through the city space, revealing the different layers of urban development, creating a linear narrative dating back to eighth-century settlements and showcasing the idea of progress in urbanity. The city walks, consequently, are no longer just a movement across the city premises (horizontally), but also a movement throughout time (vertically). This development was a step away from the city representation and how it was done until the 1960s. Instead of pointing out the importance for the Polish national identity at each building, Piskorski organised them in clusters regarding the desired time layers.

Generally, while the city was represented in the early twentieth century as an accumulation of buildings of a specific function, the linear narrative of city walks paved a new way through the urban space, dividing it into mental segments. The representation of each district according to a time layer adds an element to the city representation, where urban space is not just seen as a premise but also as a historical space with a time element. The comparison shows the underlying structures revealed in the guidebook conception, which were taken as common sense in their respective time. The comparison and overarching approach indicate that the structures are not dependent on the nation or language the authors speak, but bridge the censure of World War II. Nevertheless, it is important to mention that the guidebook (German or Polish) covers the city premises which emerged until 1910, even though the city expansion after this date was equally enormous. Several districts with their monuments and meaning for the city remain, therefore, invisible in the

representation. Moreover, the different "steps" of city development have gaps of several hundred years, which is another example of the selectiveness of guidebook creation.

Considering the different types of guidebooks (listings versus narrative elements) poses the question of what the city is in the eye of the authors as local actors. At the beginning of the century, one could argue, due to the guidebook structure, that the city is seen as a dense accumulation of buildings that can be named and located within close premises. When more narrative elements occur, and city walks make sense of the accumulation of single components; the focus shifts more towards the social interaction, and the events and history of the places. With the professionalisation of tourism in the 1970s and the growing complexity of the city, representation changes again. By choosing areas as representatives for urban developments, the city space is, on the one hand, simplified since a singular sight needs less explanation. On the other hand, by changing the linear narratives of city walks into areal descriptions, a fourth dimension, the timely element, is added to them. Therefore, the city space is growlingly represented as a density of social interactions of the past, which are made visible.

Appendix

Figure 4.1 Fragment of map of Szczecin showing the "Old Town," "New Town," and newly built streets after 1872 with the underlying borders of the former fortifications. © Staatsbibliothek zu Berlin – Kartenabteilung.

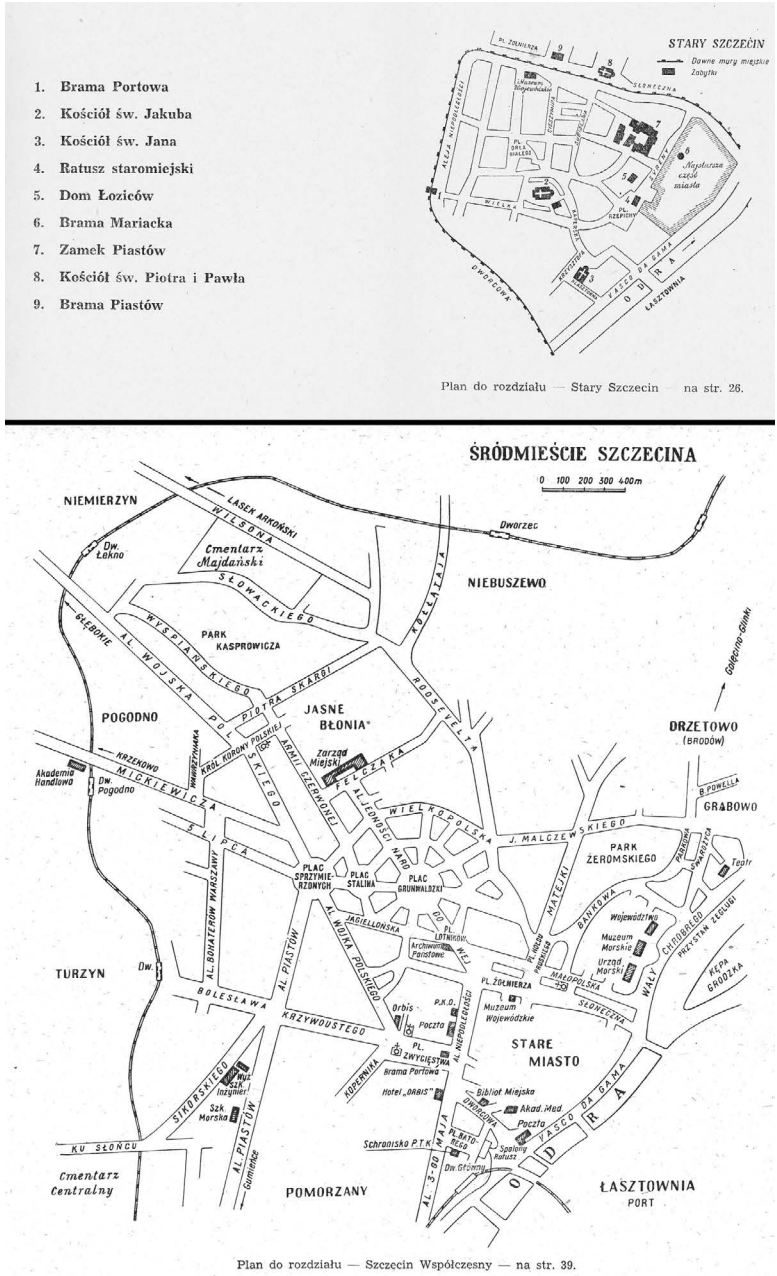

Figure 4.2 Guidebook map from 1948 to accompany the suggested city walk "Old Town" and "Centre Szczecin" (similar to "New Town" and the area after the dismantling of the fortification). Even though only two fragments from the medieval city walls survived, the mental division for walking tours remained (Piskorski 1948, 26, 39).

Notes

1 This chapter is a component of a larger ongoing research project on 'Urban Authenticity in Szczecin' as part of the author's dissertation. More information is available here: https://urban-authenticity.eu/
2 Cf. Roland Barthes, *Mythologies* (New York: Noonday Press, 1972), p. 76.
3 The term "sights" is used critically, since they are city elements to which a specific group or community attributes meaning. Guidebooks communicate and contribute to this process.
4 Cf. Barthes, *Mythologies*, p. 10.
5 This paper refers to the city of Szczecin under its Polish name of today. This does not exclude the town's history under the German name Stettin, the official designation until 1945. For the sake of avoiding confusion, this text coherently uses the Polish name even when the topic covers the city's history before 1945.
6 Cf. Barthes, *Mythologies*, p. 75.
7 Cf. Victoria Peel and Anders Sørensen, *Exploring the Use and Impacts of Travel Guidebooks*. Tourism and Cultural Change 48. (Bristol, Buffalo, Toronto: Channel View Publications, 2016).
8 Cf. John Towner, "Approaches to Tourism History," *Annals of Tourism Research* 15, no. 1 (1988): p. 49, https://doi.org/10.1016/0160-7383(88)90070-9.
9 Cf. John Urry, *The Tourist Gaze*: *Leisure and Travel in Contemporary Societies*, Reprint. Theory, Culture & Society (London: Sage Publications, 1997).
10 Cf. Adrian Franklin, *Tourism: An Introduction* (London: Sage, 2003), pp. 97, 103.
11 Cf. Peel and Sørensen, *Exploring the Use and Impacts of Travel Guidebooks*, p. 5.
12 Cf. Andrew McGregor, "Dynamic Texts and Tourist Gaze," *Annals of Tourism Research* 27, no. 1 (2000): p. 46, https://doi.org/10.1016/S0160-7383(99)00034-1.
13 Cf. Peel and Sørensen, *Exploring the Use and Impacts of Travel Guidebooks*, p. 6.
14 Cf. Dean MacCannell, "Staged Authenticity: Arrangements of Social Space in Tourist Settings," *American Journal of Sociology*, vol. 79, no. 3 (1973): p. 598.
15 Gerard Labuda and Bogdan Wachowiak, eds., *Dzieje Szczecina*: *1806–1945*, (Szczecin: 13 MUZ, 1994); Gerard Labuda and Tadeusz Białecki, eds., *Dzieje Szczecina*: *1945–1990*, (Szczecin: 13 MUZ, 1998); Jan M. Piskorski et al., eds., *A Short History of Szczecin* (Poznań: Poznańskie Towarzystwo Przyjaciół Nauk, 2002); Jörg Hackmann, "Stettin/Szczecin," in *Online-Lexikon zur Kultur und Geschichte der Deutschen im Östlichen Europa* (2015), last modified July 30, 2021, http://ome-lexikon.uni-oldenburg.de/p32459.
16 Jan Musekamp, *Zwischen Stettin und Szczecin*: *Metamorphosen einer Stadt von 1945 bis 2005,* Veröffentlichungen des Deutschen Polen-Instituts Darmstadt 27 (Wiesbaden: Harrassowitz, 2010; PhD diss., Viadrina University Frankfurt/Oder, 2008).
17 Due to the travel regulations, most West and East Germans could or would not travel to Szczecin until the 1970s. Therefore, onsite knowledge of the city which had suffered war destruction and been reshaped by reconstruction projects was limited. The analysis of the representation of Szczecin after World War II by German actors and former inhabitants is a different research question, which would go beyond the scope of this chapter.
18 Cf. Stettiner Touristen-Klub, *Empfehlenswerte Pommersche Sommerfrischen* (Stettin: Herrcke & Lebeling, 1906).
19 Cf. Carl Friedrich Meyer, *Großer Plan von Stettin*: *Nebst Kurzer Erläuterungen und Führer durch Stadt und Umgegend*, 6th ed. (Stettin: Hermann Saran, 1901).
20 Cf. Bogdana Kozińska, *Rozwój Przestrzenny Szczecina*: *Od Początku XIX Wieku do II Wojny Światowej* (Szczecin: Kampol, 2002), p. 245.
21 Cf. H. Ploetz, *Auto-Omnibus Rundfahrten durch Stettin* (Stettin: Stettiner Verkehrsverein, 1925); Lina Rosenberg, *Ein Tag in Stettin* (Stettin: Stettiner Verkehrsverein, 1928); Lina Rosenberg, *Kurzer Besuch in Stettin* (Stettin: Stettiner Verkehrsverein, [1928]).
22 Cf. Kristin Semmens, *Seeing Hitler's Germany*: *Tourism in the Third Reich*, (Basingstoke, Hampshire: Palgrave Macmillan, 2005; PhD diss., Cambridge University, 2003), pp. 7–8.

23 Cf. Semmens, *Seeing Hitler's Germany*, p. 32.
24 Cf. Semmens, *Seeing Hitler's Germany*, p. 40.
25 Cf. Semmens, *Seeing Hitler's Germany*, pp. 96–97.
26 Cf. Karla König, "Frohe Botschaft!," *Amtliches Nachrichtenblatt des Stettiner Verkehrsvereins G.m.b.H.* vol. 7, no. 24 (1933): p. 2.
27 Cf. Bogdan Frankiewicz, "Wojenne Losy Szczecina," in *Dzieje Szczecina: 1806–1945*, eds. Gerard Labuda and Bogdan Wachowiak (Szczecin: 13 MUZ, 1994), p. 878f.
28 Cf. Polskie Towarzystwo Krajoznawcze, *Informator Szczeciński*: *Z Orientacyjnym Planem M. Szczecina* (Szczecin: Orbis, [1946]), p. 7.
29 Czesław Piskorski (1915–1987) was one of the first and best known figures in Polish tourism in Western Pomerania. During World War II, while imprisoned in the German concentration camp Mauthausen-Gusen, he was a member of the resistance group organised by Leon Królak. They prepared to set up Polish publishers quickly after the war to compensate for the attempted obliteration of Polish culture. Piskorski moved to Szczecin on 17 August 1945, to set up the publishing house "Polskie Pismo i Książka". He would, among others, initiate the newspaper "Pionier Szczeciński" and the first map of the Polish street names in Szczecin. In 1967, he was appointed manager of the Departments of Tourism Development (*Zakład Zagospodarowania Turystycznego*) and later the Institute of Tourism (*Instytut Turystyki*). He was highly influential, e.g. in his professional work, as a local actor, as a founder of the PTTK branch in Szczecin in 1946, and as a tourist guide and author (cf. Katarzyna Zwierzewicz, "Czesław Piskorski (1915-1987): Pisarz i wydawca." Paper presented at Ludzie Książki Pomorza Zachodniego, online symposium, Szczecin, May 2020. https://www.youtube.com/watch?v=i1HTnmBY4gE.) His books educated Polish settlers from different backgrounds in the Western territories, therefore integrating the region into the mainland. With his position in the committees, he greatly influenced the distributed narrative of *Ziemie Odzyskane* ("recovered territories"). He was a member of the Polish Union of the West, promoting the Oder-Neisse line as the border, and a believer in the Re-Polonisation of Szczecin (cf. Musekamp 2010, p. 87.)
30 The PTK was initially founded in 1906 in Warsaw to teach youth and adult Poles about the territories of the Polish Kingdom with excursions, travels, exhibitions, etc., in a time when the nation of Poland did not exist on official maps. The growing popularity led to the opening of several regional offices. With the office in Szczecin, their goal was to explicitly evoke admiration for Poland and its culture and to participate in the protection of cultural and natural monuments and the native traditions in Poland. Polskie Towarzystwo Krajoznawcze, *Statut PTK* (1946, p. 3f.) In 1950 the PTK was offically dissolved and replaced by the PTTK (cf. Janusz Umiński, "Działalność Administracji Państwowej w Dziedzinie Turystyki na Kujawach i Pomorzu w Latach 1945–1975," in *Od PTK do PTTK: Studia i Materiały z Dziejów Krajoznawstwa Polskiego*, eds., Wanda Skowron and Janusz Umiński, Warszawa: Zarząd Główny Polskiego Towarzystwa Turystyczno-Krajoznawczego, 2009, p. 211.)
31 Cf. Walne Zebranie Polskiego Towarzystwa Krajoznawczego Oddział Szczecin-Miasto (11 April 1948) by PTTK – Zarząd Okręgu w Szczecinie. 65/507/0/2.7/31, Archiwum Państwowe, Szczecin, p. 13.
32 Cf. Umiński, "Działalność Administracji Państwowej w Dziedzinie Turystyki na Kujawach i Pomorzu w Latach 1945–1975," p. 210.
33 Cf. Opracowanie "50 lat Szczecińskiego Oddziału PTTK 194–1996. 50 lat przewodnictwa turystycznego w Szczecinie 1948–1998," by Polskie Towarzystwo Turystyczno-Krajoznawcze Regionalny Oddział Szczeciński im. Stefana Kaczmarka. 65/1751/0/7/113, Archiwum Państwowe, Szczecin, p. 27
34 Piotr Zmyślony and Marek Nowacki, "From Centrally Driven Variations to Market-driven Development: Models of Urban Tourism Evolution in Poland." In *Tourism Development in Post-Soviet Nations: From Communism to Capitalism*, eds Susan L. Slocum and Valeria Klitsounova, Springer eBook Collection (Cham: Palgrave Macmillan, 2020).

35 Cf. Marcin Majowski, *Polska Ludowa zaprasza*: *Polityka turystyczna w czasach Edwarda Gierka,* W Krainie PRL (Warszawa: Trio, 2008), p. 19.
36 Cf. Julia Wagner, "Emotional Inventories: Accounts of Post-War Journeys 'Home' by Ethnic German Expellees," in *Tourism and Memories of Home: Migrants, Displaced People, Exiles and Diasporic Communities*, ed. Sabine Marschall (Bristol, Blue Ridge Summit: Channel View Publications, 2017), p. 71, https://doi.org/10.21832/9781845416041-006
37 Cf. Czesław Piskorski and Jerzy Kosacki, "Turystyka," in *Dzieje Szczecina: 1945–1990*, eds Tadeusz Białecki and Zygmunt Silski (Szczecin: 13 MUZ, 1998), p. 676.
38 Cf. Zmyślony and Nowacki, "From Centrally Driven Variations to Market–Driven Development," p. 51.
39 Cf. Meyer, *Großer Plan von Stettin*, p. 19ff. Carl Friedrich Meyer, *Großer Plan von Stettin*: *Nebst Verzeichnis der Strassen und Öffentlichen Einrichtungen*, 7th ed. (Stettin: Hermann Saran, 1907).
40 Cf. *Stettin Und Umgegend*: *Ein Zuverlässiger Führer für Einheimische und Fremde*, 3rd ed. (Stettin: Hermann Saran, [1905]).
41 Cf. *Stettin Und Umgegend*: *Ein Zuverlässiger Führer.*, 4th ed. (Stettin: Hermann Saran, [1908]). *Stettin Nebst Umgebung*, 5th ed. (Stettin: Herman Saran, 1911)
42 Cf. *Stettin Und Umgebung*: *Provinzialhauptstadt* (Stettin: Stettiner Verkehrsverein, 1912), pp. 2–3.
43 Cf. Georg Hannig, *Stettin*: *Ein Werbebuch* (Stettin: Stettiner Verkehrsverein, [1920]), pp. 5–9.
44 Cf. *Stettin* (Stettin: Stettiner Verkehrsverein, 1922).
45 Cf. Ploetz, *Auto-Omnibus Rundfahrten durch Stettin*.
46 Cf. Lina Rosenberg, *Ein Tag in Stettin* (Stettin: Stettiner Verkehrsverein, [1925]); Rosenberg, *Ein Tag in Stettin*; Rosenberg, *Kurzer Besuch in Stettin*.
47 Cf. Polskie Towarzystwo Krajoznawcze, *Informator Szczeciński*, p. 10.
48 Cf. Czesław Piskorski, *Zabytki piastowskiego Szczecina*, 2nd ed. (Szczecin: Polskie Pismo i Książka, 1947).
49 Up until 1958, the castle of the Pomeranian Dukes was the primary identification point to connect Szczecin with the Piast nobility–the historical reference to claim the Western territories as "re-covered" (*Ziemie Odzyskane*) Polish lands. In 1958, Professor Gerard Labuda proved that connection of the Pomeranian dukes, the castle builders, was not significantly closer to the Piasts than other European nobility. Therefore, the regional identification with the Pomeranian dukes took over and the castle as one of the main attraction points prevailed. (cf. Musekamp, *Zwischen Stettin und Szczecin*, p. 151).
50 Cf. Czesław Piskorski, *Morskie Miasto Szczecin*, Popularna Biblioteka Krajoznawcza 19, (Warszawa: Kraj, 1950), p. 7; Czesław Piskorski, *Województwo Szczecińskie*: *Przewodnik* (Warszawa: Sport i Turystyka, 1966), p. 64.
51 Cf. Czesław Piskorski, *Szczecin i Dolne Przyodrze*: *Przewodnik,* Biblioteczka Krajoznawcza 1 (Warszawa: Czytelnik, 1948); Czesław Piskorski, *Szczecin i Okolice* (Warszawa: Kraj, 1953); Czesław Piskorski, *Szczecin i Okolice*: *Przewodnik*, 2nd ed. (Warszawa: Sport i Turystyka, 1960); Czesław Piskorski, *Szczecin i Okolice*, 3rd ed. (Warszawa: Sport i Turystyka, 1965); Czesław Piskorski, *Szczecin*: *Informator Turystyczny* (Warszawa: Interpress, 1968); Piskorski, *Morskie Miasto Szczecin*.
52 Cf. Piskorski, *Szczecin i Okolice*, p. 19ff.
53 Cf. Piskorski, *Szczecin i Okolice*, p. 21ff.
54 Cf. Katja Bernhardt and Jan Musekamp, "Przełom roku 1945? Urbaniści w Stettinie i w Szczecinie," in *Odbudowa Miast Pomorza Zachodniego po Drugiej Wojnie Światowej: Wybrane Problemy*, ed. Paweł Migdalski (Poznań, Bogucki: Wydawnictwo Naukowe; Stargard, Szczecin: Muzeum Archeologiczno-Historyczne w Stargardzie, 2021), p. 186.
55 Cf. Marian Rębkowski, "Badania Milenijne na Pomorzu Zachodnim: Przebieg, Znaczenie, Skutki," *Przegląd Archeologiczny*, no. 65 (2017): p. 118.
56 Cf. Hasso Spode, "Romantische Zeitreise: Eine Theorie des Tourismus," *Kulturelemente*, no. 109 (2013): p. 3.

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5 How names transform space

The change of street names in Poznań and Gdynia in the nineteenth and twentieth centuries

Grigori Chlesberg

The question posed in this part of the book is "What constitutes the town?" This question is complex and can therefore be answered in different ways, as already partially described in other chapters. One essential answer for making space – including urban space – addressable and therefore usable in the first place is geographical names. Such names can be found everywhere – country names, administrative units (e.g. federal states, voivodships), city names or rivers, mountains, and street names, to list but a few. Each act of naming, provided it becomes common knowledge, gives users the possibility to indicate a geographical unit precisely defined to other users. I can only speak of being in Marburg because I, as well as most other people, know and associate the name with a place, or rather, if they don't know it, are able to look it up in maps or gazetteers, as well as the Internet or Google Maps. Names are synonymous to the possibility of making distant space accessible and usable beyond the horizon of one's own imagination and observation. Names therefore may be considered as identifiers or distinctive attributes of any locality. However, this is precisely where the challenge lies. Names must be valid for all people involved. This is a problem even today, despite databases, navigation, and the Internet. It becomes even more difficult as soon as another level is brought into play, namely that of time. Several factors play a role here: names change, they are and were not used by all actors, and they can also vary in their spelling or the language used. Especially in areas that changed ownership between different empires in time, as well as being reshaped by different cultural and national groups, such changes are found to a high extent.

The natural space remains mostly the same, the constructs, be it the cities themselves, infrastructure, or the names to be used, change. Different actors recognized that the space surrounding them had to be named. Various factors, some of which are still valid today, play a role in this. They can be attributed to two areas in a simplified way: on the one hand, the development of infrastructure and administration, and on the other, the legitimization of ownership rights. What people often were not aware of was that they created spatial orders. Most of them were functioning among themselves, but were not necessarily compatible with each other. Especially with the widening horizons of contemporary witnesses of the nineteenth century, such spatial orders extended to counties, parts of countries or even entire states – in

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times of global trade and digitization, they even extend to the whole world. In addition to the pure naming of space, the assignability of names also grew. Names became part of certain systems, which caused their unambiguousness and unambiguous spelling, as well as their distinctness, to become a necessary feature. Timetables, city maps, postal directories, and gazetteers were created and presupposed that person A was aware of the same functioning of names as person B. To consider all the necessary areas for this would far exceed the size of one chapter in this anthology. The focus will therefore be on an area that began to play a greater role with the emergence of national patterns of thought and nation states: spatial construction as a cultural and national acquisition process. As today's Republic of Poland offers a turbulent history marked by sovereign and territorial changes, it is particularly suitable for the presentation of such processes. For the rest of the chapter, we will therefore look at developments in Poland in the nineteenth and twentieth centuries, and explicitly at the two cities of Poznań and Gdynia, which lie in the former territories occupied by Prussia.

Spatial construction as part of a national acquisition process

The cultural and national acquisition of Polish space by Prussia requires a brief history: the three partitions of the Polish-Lithuanian Commonwealth between Brandenburg-Prussia, the Russian Empire and the Habsburg monarchy in 1772, 1793, and 1795 marked the end of a sovereign Polish state until the twentieth century. The very naming of the new Prussian provinces shows how they were to be recoded and integrated by naming, when space was acquired. The former Polish voivodships became the provinces of West Prussia, in parts East Prussia, South Prussia, New East Prussia, and New Silesia. Descriptions of the landscape, towns, and villages were also written during this period. Remarkably, such descriptions often contain different variants of the place names. For example, a description of South Prussia and New East Prussia from 1798 contains the formulation "Posen, pol. Poznan, lat. Posnania."[1] Although this omits Polish diacritics, it shows nevertheless three different forms of the name without referring only to the German form. Another source from 1799 has a similar formulation: "the Posen District is a part of the former Posen Voivodship – in Polish Wojewodztwo Posnanskie; in Latin Palatinus Posnaniensis."[2] The name of the city is also given as "Posen or Poznan."[3] The use of the word "or" in particular shows a juxtaposition of the names; the German one is not given preference here. Although the texts certainly offer the idea of a German city of Posen, national appropriation does not take place here, but the elements of the city attributed to the Germans are positively emphasized – the authors' prejudices cannot be considered equivalent to a Germanisation.

Developments in the early nineteenth century gradually changed the situation. The November Uprising of 1830/1831 initially triggered a "Polish enthusiasm." In the 1840s, however, German society came to a realisation: German and Polish claims to national space were bound to lead to conflict.[4] A German state foundation in 1848 failed. Nevertheless, both the provinces of Prussia and Posen belonged to the Deutsche Bund from 1848 to 1851. At the same time, the "nation as a political

concept of order"[5] was established. Geographical names were also used to legitimize national claims. In addition to the benefits for the administration in the territorial state, there was now the gradual use as identifier in the nation state as well. At the latest in 1867, with the founding of the Norddeutsche Bund, and in 1871 with the founding of the German Empire – both of which also included the provinces of Posen and West Prussia – place and street names, as well as historiography, linguistics, and cartography, were instrumentalised to legitimise German claims. Subjects of a kingdom now became citizens of a German nation state,[6] the Polish population a minority in this body politic. Following the logic of the nineteenth century, this state had to be homogeneously "German" and leave no doubt about its external image. Numerous changes took place in the following years. German became the only business language of the authorities in 1876.[7] Polish names disappeared from place-name signs, which often still bore Polish and German place names, especially in the province of Posen.[8] In 1901, a standardised German orthography was introduced.[9] The German language, now a national language, rapidly gained importance. These developments pushed forward a phase of increased Germanisation.

Poznań-Posen

Social development, especially fuelled by new forms of mobility as well as industrialisation and the accompanying need for wage labourers, changed cityscapes, and, above all, ensured a steady expansion of cities. The nationalisation of society and the founding of the German Empire led to increased self-image as German cities. Both developments were to have an impact on Posen as well. At the end of the nineteenth century, the city's fortifications were dismantled. The resulting space, as well as the unfolding of the city to the outskirts, opened up new areas. It would have been possible to use such an area for general urban development, for instance for housing projects. Instead, following the zeitgeist, the royal committee in Posen used it for a new representational German quarter. Until then, centres of Polish and German life had been spread throughout the city. The newly created Schlossviertel (castle quarter) formed a new, self-contained government district, which was to leave no doubt about the German character of the city. Many characteristic buildings were erected, such as the Kaiser-Friedrich-Museum, the Kaiser-Wilhelm-Library, the headquarters of the Ansiedlungskommission, a theatre or a new imperial palace. In a very short period of time, just about ten years, the cityscape was fundamentally changed, and at the same time it was clearly oriented more towards the West and created a sign of a German capital "Posen" that could not be overlooked.[10]

These representative buildings changed the space deeply. In addition to the buildings themselves, new streets were laid out, traffic routes were changed, and the streets were named according to the zeitgeist, just like the building projects. If we place two maps of the city from 1897 (Figure 5.1) and 1912 (Figure 5.2) next to each other, we will see the immense changes in direct comparison. The map from 1897 (Figure 5.1) already shows almost only German street names and illustrates the change in the perception of the city since the partitions of Poland. The city ends

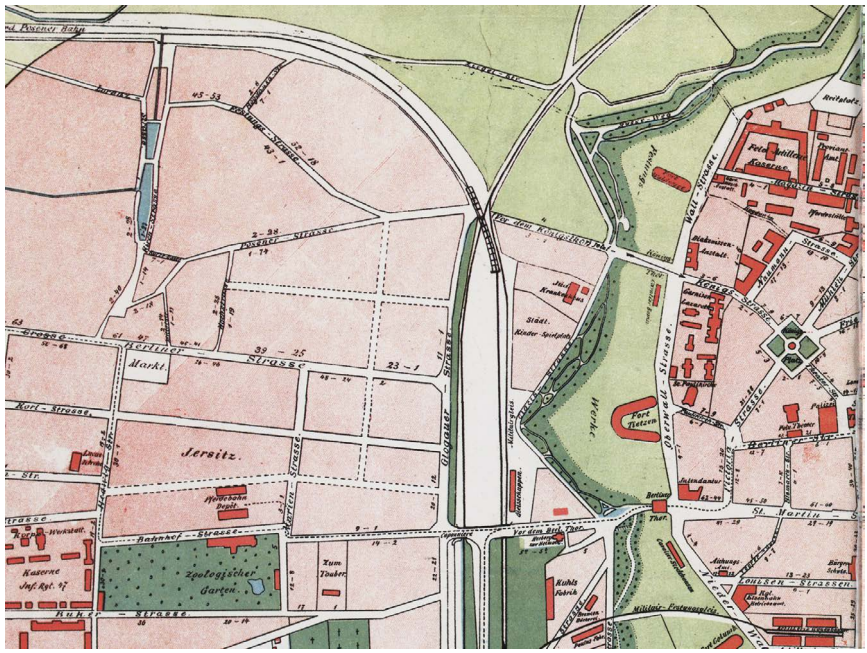

Figure 5.1 The cityscape of Posen/Poznań to the west in 1897 is characterised by the fortifications. The city has a closed structure towards the inner part. There are hardly any street names in the outer district of Jersitz. The street names within the city are written in German, but do not suggest an immense Germanisation of the cityscape. Fragment of the map: R. Oschman, Plan der Stadt Posen nebst Vororten von der "Hansa" in Posen [map] (Magdeburg-Frankefelde: Verlag von R. Oschman, 1897).

with Oberwall-Strasse and the fortifications in the right segment of the map. To the left of the wall is Jersitz (Polish: Jeżyce), where hardly any street names can be found in 1897.

The map from around 1912 (Figure 5.2) shows a very changed townscape. The former city wall is barely recognisable, only the location of Oberwall-Strasse suggests where a city wall used to be. This street is now followed by the Königs-Ring. The buildings of the new boulevard are particularly highlighted, a new bridge, the Theaterbrücke, creates an additional access to the boulevard and is also named after the new theatre. The naming of the Schloßbrücke follows the same pattern. To the right of the former city boundary, representative city parks are laid out; in the upper end, for example, there is the Goethe Park, which is given a prominent name. To the left of the former city boundary, which is hardly marked with street names on the previous map, you probably find the most characteristic name changes. Names such as Hohenzollern Str., Wittelsbacher Str., Wettiner Str., Habsburger Str., and Hohenstaufen Platz follow one another. All the new street names on the map are either related to German culture, German aristocratic houses, or

Figure 5.2 The map of Posen/Poznań, published just about 15 years later in 1912, shows a significantly changed cityscape. A fringe district has now become a representative district that leaves no doubt about its German identity. The representative buildings and the street names show a strong and rapid Germanisation of the city, as well as an increased orientation to the West. Fragment of the map: Pharus-Plan Posen (Berlin: Pharus Verlag, ca. 1912).

the new Schlossviertel. In this way, the newly created cityscape is also given an unmistakable sign in the language of the names. The transformation of the city of Posen within the German Empire illustrates how urban spaces and the names they contain were used to recode national patterns of legitimacy.

The new quarter could not last long in its form. The World War I meant the end of Prussian/German rule over the province of Posen. In August 1919, the voivodship of Poznań was founded – the capital "Posen" of the German province thus became the capital "Poznań" of a Polish voivodship. The understanding of national space was far more evident after the World War I than before. In the following years, both the Weimar Republic and the Second Republic of Poland removed many traces of each other by changing place names, field names, river names, and street names. National legitimisation became the decisive factor in naming issues. Especially, in the case of a voivodship capital as Poznań, neither the street names nor the Prussian/German Schlossviertel could simply be left as they were.

The westward orientation was eliminated in 1925, when suburbs to the east of Poznań were incorporated. The focus of the city centre thus moved more towards the old town again, and the Renaissance-style town hall on the central square of the old town became a central point once more. The city administration also resided

here. The new Schlossviertel was to be transformed in its meaning. The Imperial Palace remained the seat of the President of the Republic of Poland, the Palace Chapel, the buildings of the Royal Academy, and the Ansiedlungskommission were used by the new university. New buildings were placed between the German monumental buildings, which remained representative in style but transformed the district. "The focus was now on academia rather than political power – the imperial family and officials were replaced by professors and students."[11] Within a short period of time, the space was transformed twice. The district is particularly interesting in this respect. It didn't even exist in this form before the German Empire, so it was a German district that now had to be integrated into a Polish-national space.[12]

Needless to say, the German street names could not be left in place either. In this way, too, the area had to be adapted to the new circumstances as quickly as possible. A commission of the city council renamed almost all the streets from April 1919 to March 1921 and the list was supplemented again in August 1926 with renaming of the suburbs newly incorporated in 1925, because such street names now also belonged to the city of Poznań and therefore had to reflect the representative character of the city.[13] A map from 1930 (Figure 5.3) illustrates the dimensions.

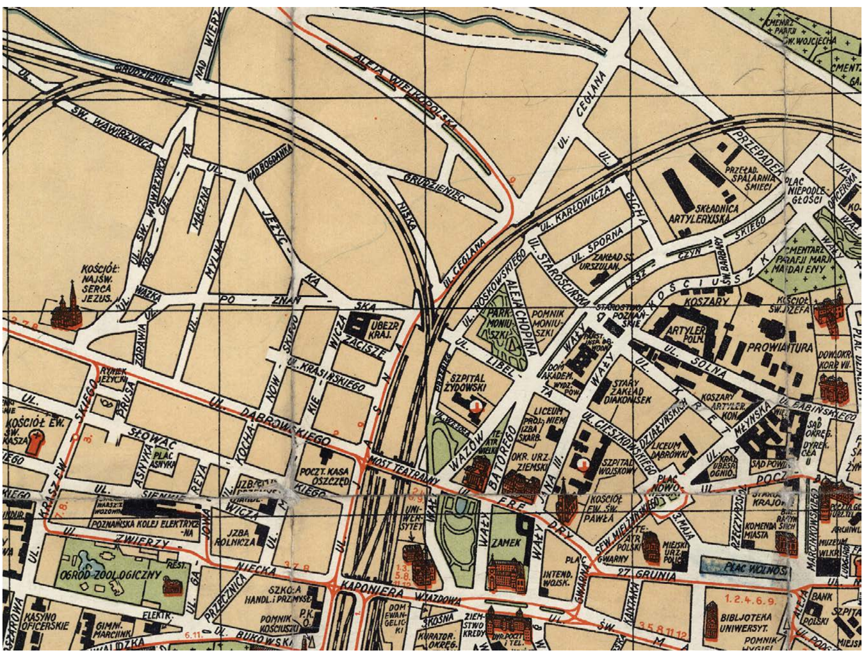

Figure 5.3 The map of Poznań from 1930 shows a very similar cityscape to the map from 1912, with only limited structural changes. Despite this, the city is clearly visible as a Polish area due to the complete renaming of all street names. Through names alone, a formerly German space is recoded as a Polish space. In times of strong hostility and nationalisation, there is no interest in a German-Polish mixed space. Fragment of the map: M. Maćkowiak, Plan Miasta Poznania [map] (Poznań: Druk. M. Maćkowiak, 1930).

There were no Polish equivalents for the castle quarter, and new names were chosen here. As the German government had already done when the Schlossviertel was built, Polish society relied on particularly representative names, high-profile personalities, and Polish history. The map is particularly interesting for distinguishing real space and spatial conception. While the street layouts on the map are almost identical to those on the previous map, the street names and names of buildings are now completely different. The map creates the image of a Polish city, whereas just a few years before it appeared completely German. Only a few names are simply translated and as in the example of the Theaterbrücke, now Most Teatralny, these names don't suggest a German background. Other streets, especially those with extreme German coding, are recoded with at least as much fortitude in Polish. The Königs-Ring, for example, becomes partly Wały Batorego, named after Stefan Batory, King of Poland from 1576 to 1586. Hohenzollern Str. becomes ul. Mickiewicza, named after the Polish national poet Adam Bernard Mickiewicz. Goethe Park becomes Moniuszki Park, named after Stanisław Moniuszko, the "Father of Polish National Opera," Berliner Str. becomes ul. 27 Grudnia, named after the day of the Wielkopolska Uprising in 1918.

The partitions of the Polish-Lithuanian Commonwealth may surely already be understood as an acquisition of space by the Prussian kingdom, yet the area remained relatively untouched at first. Place names or street names were mostly only recorded for administrative purposes and the names used outside of these purposes initially remained without further significance. Posen/Poznań itself could remain a city with two faces. It was only through social mobilisation, i.e. the exchange of human labour, especially across the entire German-speaking area and the national charging of names, that conflict hotspots emerged. With a German national space, the content of this space had to be unmistakably German-coded. The same happened after the Polish government took over. In the further course, the space was also repeatedly renamed. Even if it seems obvious to reintroduce the old names, each society had redesigned the space. During the Nazi regime, street names such as Litzmannallee, after NSDAP politician Karl Litzmann, or Obersalzberg Allee, Mountain Court of Adolf Hitler, appeared. In the post-war period, in the People's Republic of Poland, Königplatz/pl. Nowomiejski became pl. Młodej Gwardii, named after an organisation of young communist writers founded in Moscow. Even today the square bears a name different from those in the Second Republic. It is called pl. Cyryla Ratajskiego, named after Cyryl Ratajski, a Polish politician and among other things, president of Poznań in the Second Republic of Poland.

Gdynia-Gdingen-Gotenhafen

The second example deals with the city of Gdynia. The city's history actually does not begin until the 1920s. Gdingen, as it was called during Prussian and German rule, was a small Kashubian fishing village. Even if some publications mention its rising importance as a holiday resort, it remained a small village with a population of 895 in 1910.[14] With the re-emergence of the Polish state in the interwar period, Poland gained access to the Baltic Sea through the "Polish Corridor," but used the

port of the Free City of Gdansk as a transhipment point for goods. An incident in 1920, during the Polish-Soviet War, led to the Polish Republic deciding to develop its own port on the Baltic Sea.

In 1922, the Polish Sejm approved the construction of a seaport in Gdynia. The harbour was first opened for use in 1923 and the new port city of Gdynia was completed in 1933. The population and area of the city grew rapidly; by 1939 the city had 127,000 inhabitants and was the sixth largest city in the Second Polish Republic.[15] The port, as a new centre of trade and a place of military self-assertion, became a symbol of the strength and of the possibilities that the new Polish state could offer against its neighbours. The city developed an extensive infrastructure that could deliver every conceivable service and consumer good that a modern city of the interwar period could offer.[16]

The beginning of the development of Gdynia, almost simultaneous with the takeover by the Second Polish Republic, allows quite a clear separation between the village of Gdingen and the city of Gdynia. In real space at the same location, they are two entirely different localities. As with the development of the castle district in Poznań, something new had been created here. And just as in the context of the German Empire and the associated national German perception, here, too, a Polish nationalism, an acquisition of space, or even the "improvement" of space, had to be clearly conveyed to the outside world via street names. If we look at a map of Gdynia from 1936 (Figure 5.4), it not only illustrates the dimensions of the town – which just 15 years earlier had been a village of about 1,000 inhabitants – but also shows the special significance of the town for the national legitimisation of the Polish state. The street names are almost exclusively charged with a national-historical meaning, only a few names have no reference to this context. On the map section, for example, we come across Skwer Kościuszki, named after Andrzej Tadeusz Bonawentura Kościuszko, Polish military engineer and leader of an uprising in 1794 against Russia and Prussia. We can also find ul. Eugeniusza Kwiatkowskiego, which also shows another peculiarity of the naming. Whereas the city administration in Poznań had refrained from choosing people who were still alive, the cityscape of Gdynia already honoured people who had made efforts for the Second Polish Republic in this short period of time. The street is named after Eugeniusz Felicjan Kwiatkowski, Minister of Industry, Finance and Deputy Prime Minister of Poland, who promoted the development of the city of Gdynia and is therefore referred to as the "Father of Gdynia." There are also streets that refer to ancient Polish history, such as ul. Władysława IV, King of Poland in the sixteenth and seventeenth centuries, and – for a brief spell – Tsar of the Russian Empire. In addition to these examples, there are numerous other street names that refer to important figures in Polish history, important dates of historical events, or historically relevant groups, e.g. ul. 10 Lutego, 11 Listopada, or Legionów.

Through the street names, it was possible to write a Polish national history that could hardly have existed in the general public during the long period of partition. Here, the names not only functioned as a national Polish legitimisation of the area, but they also became a geographical textbook for the population and they conveyed

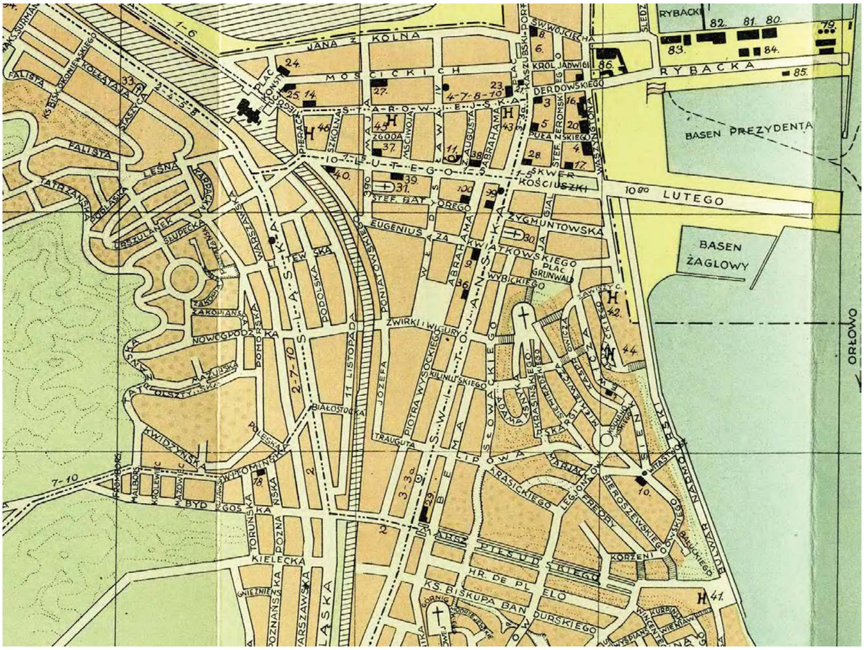

Figure 5.4 The city of Gdynia was built in slightly more than ten years. It was the pride of the Second Polish Republic and a sign of the power of the newly created state. The cityscape with its street names served as an embodiment of Polish history and Polish personalities in world history. Fragment of the map: Wielka Gdynia [map] (Gdynia: Morska Agencja Reklamy, Gdynskie Biuro Informacyjno Budowlane, 1936).

the proud history of the Polish nation to tourists and seamen through the international status of the harbour.

Only 20 years after regaining its sovereignty, the Second Polish Republic was divided between the German Empire and the Soviet Union at the beginning of the World War II in 1939. The Nazi regime began an unprecedented Germanisation of large parts of East-Central Europe. Geographical names were also to be replaced by German ones as quickly and completely as possible. One symbolic (and possibly the first official) renaming was that of the city of Gdynia to Gotenhafen. An interesting source for this fact is the work of the then Oberpostrat (Chief Postmaster) Hawlitzky. According to him, the conferment took place with the declaration of the "Reichskriegshafen" on 28 November 1939.[17] The place name itself, however, probably appeared earlier. In a copy of the "Gaumuseum for West Prussian History" various possibilities are offered – among others "Gotenort, Öxhöf, Wiekort, or Wiekstadt."[18] On the letter is a handwritten note from the Gauleiter of Danzig-West Prussia: "the Führer has spoken out in favour of the name Gotenhafen."[19] The copy bears no date. Another letter states that "this suggestion was made between 15 and 18 September 1939."[20] The special interest and the fact that Adolf Hitler

personally decided on the place name can be deduced from the significance of the port city. It had become "virtually a symbol of Polish success and will to survive […] the beginning of the Germanisation of the territories to be annexed in this city of all places simultaneously set a symbolic sign."[21] The name of the town is also interesting at this point. The choice of old Germanic names of ethnicities or Germanic-mythological terms was not uncommon from 1939 onwards, such as the example of Kruschwitz, which was renamed Wikingen (after Vikings).[22] Especially in such cases, clear differences between the German nationalist and National Socialist ideological names were evident.

Like the very early, representative renaming of the city itself, the street names were also intended to create a Nazi-German space. Just like the Second Republic of Poland in the castle district in Poznań, the Third Reich had no German street names available for the still young city. Therefore, all names had to be created anew. The procedure was similar to that for the street names of the city of Gdynia. Gotenhafen was given names of well-known Nazi personalities, German historical figures as well as poets and historically relevant events (Figure 5.5). There is an Adolf-Hitler-Str. (ul. Świętojańska) and an Adolf-Hitler-Platz (Skwer Kościuszki), as well as a Hermann-Göring-Str. (ul. 10 Lutego), both from the highest circles of the Nazi

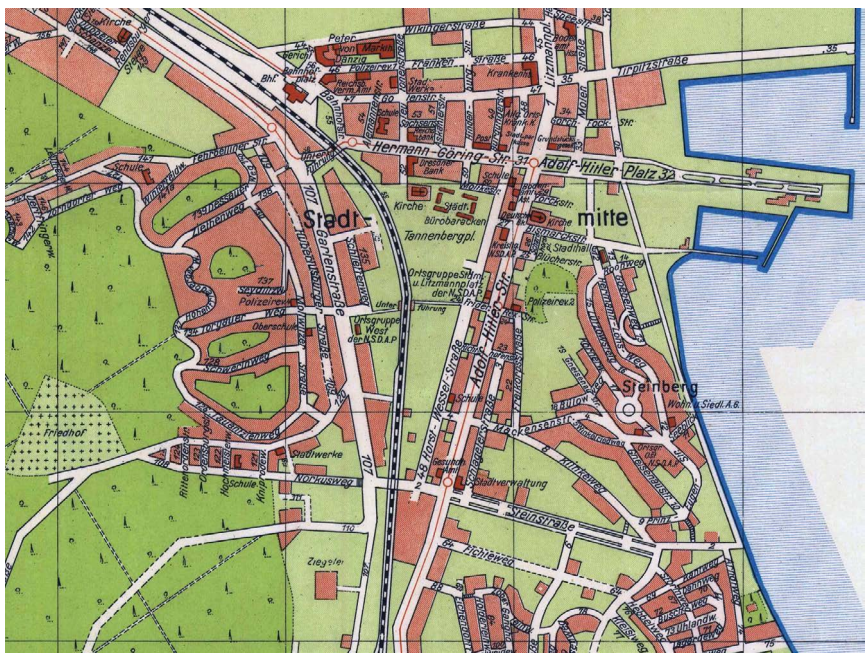

Figure 5.5 Gotenhafen, as Gdynia was called from 1939, was completely renamed. From the name of the town to every street name, everything was Germanized. Instead, very meaningful street names were chosen, which were intended to emphasize the Nazi ideology, its history, and high-profile personalities of the regime. Fragment of the map: Gotenhafen [map] (Berlin: Lithographisches Institut, 1943).

state. Likewise, a Bismarckstr. (ul. Eugeniusza Kwiatkowskiego) and a Hindenburgstr. (ul. Władysława IV), to create a reference to German history, as well as a Schillerstr. (ul. Legionów), with a reference to German poets. In part, however, it was probably only for the purpose of overwriting the most important events in Polish history, such as the renaming of ul. 11 Listopada to Gartenstr. (Garden Street). Other street names were Litzmannplatz, Tirpitzstr., Wikingerstr., or Moltkestr.

Here again, the two map sections (Figures 5.4 and 5.5) show how the infrastructure of the city hardly changes, yet two completely different spatial concepts emerge through the geographical names. Particularly due to the expansion of the port city of Gdynia, not until the 1920s and its renaming as Gotenhafen in 1939, it is almost possible to speak of two completely different cities, which again have no relation to the fishing village of Gdingen. While Gdynia can be seen on the map as a kind of textbook of Polish national history, Gotenhafen is a manifestation of Nazi ideological ideas of German history and society through its street names. Without the real space but through geographical designations, in the form of gazetteers, maps, etc., it can be assumed that two entirely different cities exist even when an address is depicted. The ul. Świętojańska, city of Gdynia, Pomeranian Voivodship, Polish Republic in a 1920–1939 gazetteer is simultaneously the Adolf Hitler Str., city of Gotenhafen, Reichsgau Danzig-Westpreußen, German Empire in a 1939–1944 gazetteer.

With the end of the World War II, there was another change in the borders. Poland was moved to the west. The aversion to the "German," as well as the created Piast myth, made it impossible for most people involved to retain the German names.[23] For example, as early as 1945 the voivode of Poznań repeatedly called for the elimination of all forms of German inscriptions, the general exclusion of the German language even in the communication of the authorities, and the renaming of shops, street names, and squares in Polish.[24]

The city of Gotenhafen, now called Gdynia again, became Polish once more. The brief German episode in the port city's 25-year history was to leave no traces. Here, too, an immediate renaming would have been possible but for the communist government of the People's Republic of Poland who had no interest in upholding memories of the Second Republic of Poland. Many of the street names, however, were reminiscent of what was perceived as a capitalist and therefore now hostile era.[25] The principle of leaving no doubt about the People's Republic, even through names, was enforced at all levels. An interesting example is the renaming of the place Niemaszchleba (Lubusz Voivodship, Powiat Gubiński) to Chlebowo. The place name Niemaszchleba, meaning as much as "you have no bread," did not fit into a socialist society, so the place was renamed in 1953.[26]

In Gdynia, many street names were changed (Figure 5.6). Ul. Eugeniusza Kwiatkowskiego became ul. 22 Lipca, named after a Peoples Republic holiday, which was celebrated every year until 1989. Ul. Legionów was even named after Feliks Edmundovich Dzierżyński, the man who founded the Cheka secret police in the Soviet Union. Ul. Lipowa was now called I Armii W.P., after the first unit of the "Polish Army Reborn" formed in the Soviet Union.

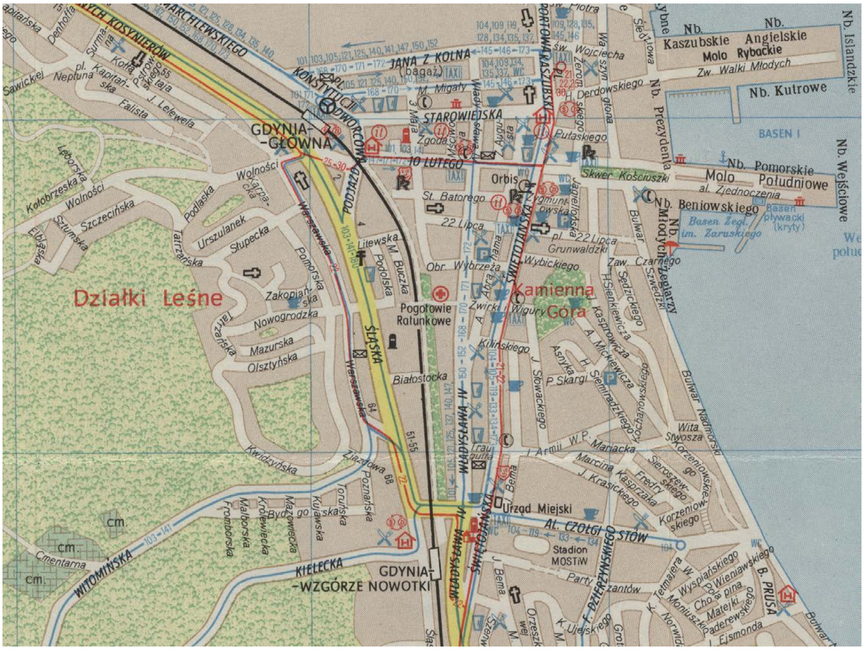

Figure 5.6 The map of Gdynia from 1977 seems almost unchanged. However, numerous street names are different from those in the Second Republic of Poland. In addition to Gdingen the fishing village, Gdynia in the Second Republic of Poland and Gotenhafen in the Nazi era, there is also a Gdynia of the People's Republic of Poland. Fragment of the map: Krystyna Zalewska [Red.], Gdynia [map] (Warszawa: Państwowe Przedsiębiorstwo Wydawnictw Kartograficznych, 1977).

These and other street names were now to write a new chapter in the city of Gdynia's history and Poland's entire past. Any names that created a reference to the "wrong" history were eliminated and ideological-Soviet names were increasingly used.

Not all street names survived here either. Gdynia today has once again eliminated the names of the People's Republic. For example, the former ul. Eugeniusza Kwiatkowskiego, later Bismarckstr. and ul. 22 Lipca now have the name ul. Armii Krajowej, named after a resistance group of the Polish Home Army during World War II. On the other hand, ul. Legionów, later Schillerstr. and ul. F. Dzierżyńskiego was renamed ul. Legionów again in the Third Republic of Poland.

Conclusions

With the rise of nationality, national languages, nation states as well as with the emergence of national borders and ideologies, such as National Socialism or the People's Republic, immense value was now ascribed to geographical names. Place names, street names, and any other geographical designations were now no longer

only supposed to be able to identify space, they created a context. They represent the respective value system, the respective history, and separate the majority from the minorities. Such renaming was usually not without reason and cannot simply be dismissed as German or Polish names. Every system, regardless of the nation it belonged to, created its own spatial order.

The two examples chosen have one thing in common. The construction of the Schlossviertel and the foundation of the harbour city of Gdynia represent a massive and rapid change in the cityscape. Here, new geographical structures are created and the space is nationally coded by street names at the same time. The following changes are of a different nature. The space remains almost the same, but the systems that structure the space change. The Schlossviertel in Posen cannot be equated with the Polish city of Poznań, as little as the village of Gdingen or the city of Gotenhafen with the port city of Gdynia. Even the Gdynia of the Second Republic of Poland and that of the People's Republic do not follow the same values. The real space remains almost the same after one-time reconstruction, the spatial orders change. Both are relevant for understanding historical developments. As in the example of the two gazetteers of Gdynia and Gotenhafen, there is a risk of separating spatial concepts and space by considering only individual geographical information.

This example in particular shows a great challenge for today's historical research. Especially when it comes to the creation of historical place-name databases (HGIS), names, in addition to e.g. information on type or coordinates, are necessary details in order to be able to locate a place (town, street, etc.) precisely, as well as to make the necessary data of a long period of time accessible. In this context, the frequent change of names raises another question. For example, are ul. Armii Krajowej, ul. Eugeniusza Kwiatkowskiego, Bismarckstr., and ul. 22 Lipca in today's Gdynia the same street? In a system that uses the name as a necessary attribute for locating further information, this theoretically results in four separate geographical objects. Digital databases offer new solutions in this context, but at the same time researchers must learn to deal with such challenges. Because the difficulty goes beyond the mere creation of data structures. Theoretical questions about the identity of a space also need to be considered. From this perspective, can one speak of an object in space retaining the same identity even though the name changes–usually connected to changes in the political system or other major historical events? Geographical names represent a key function in this context. The knowledge about the change of such names is at the same time the knowledge about superordinate processes.

The question about the identity of an object in space with changing attributes, in this case the name, can hardly be answered so simply and is to be evaluated differently, depending on the intended gain in knowledge, as well as the respective discipline or the time period investigated. The extent to which the historical background of a geographical name determines our evaluation can be illustrated here, at least superficially. For example, it is certainly easier from today's perspective to allow a common history and thus also a certain equation of Posen and Poznań, whereas a common history of Gdynia and Gotenhafen requires considerably more abstraction and a far greater differentiation.

Geographical knowledge systems therefore pose a challenge for research. On the one hand, they can serve to gain a deeper idea of the respective conception of the world from street or place names. On the other hand, knowledge of all the necessary geographical designations is a requirement for examining historical sources and relating them to each other across different time periods.

Notes

1 Historisch-statistisch-topographische Beschreibung von Südpreußen und Neu-Ostpreußen oder der königlich-preußischen Besitznehmung von Polen in den Jahren 1793 und 1795 entworfen: Erster Band mit Sechs Kupfertafeln und drej Landkarten (Leipzig, 1798), p. 381.
2 Friedrich Gottlob Leonhardi, Erdbeschreibung der preußischen Monarchie: Fünfter und letzter Band (Halle, 1799), p. 54 [translated by author].
3 Ibid., p. 56 [translated by author].
4 Cf. Manuela Uhlmann and Rainer Pommerin, ed. Quellen zu den Deutsch-Polnischen Beziehungen 1815–1991 (Darmstadt: Wissenschaftliche Buchgesellschaft, 2001), p. 7 ff.
5 Christian Pletzing, Vom Völkerfrühling zum nationalen Konflikt: Deutscher und polnischer Nationalismus in Ost- und Westpreußen 1830–1871 (Wiesbaden: Harrassowitz, 2003), p. 311 [translated by author].
6 Cf. Christoph Kleßmann and Johannes Frackowiak, "Die Polenpolitik des Deutschen Kaiserreichs 1871–1918," in Nationalistische Politik und Ressentiments: Deutsche und Polen von 1871 bis zur Gegenwart, ed. Johannes Frackowiak (Göttingen: V&R Unipress 2013), p. 25.
7 "Gesetz über die Geschäftssprache der Behörden, Berlin, 28. August 1876," in Quellen zu den Deutsch-Polnischen Beziehungen 1815–1991, ed. Manuela Uhlmann and Rainer Pommerin (Wiesbaden: Harrassowitz, 2003), p. 67.
8 Cf. Hartmut Gräber, Die Ortstafeln in der preußischen Provinz Posen 1820–1918: Eine Facette im Sprachenstreit (Herne: Martin-Opitz-Bibliothek, 2020), p. 26; Hartmut Gräber, Ortstafeln mit militärischen Bezeichnungen im Deutschland des 19. und frühen 20. Jahrhunderts: das Ergebnis einer Recherche (Norderstedt: BoD, 2021), p. 41.
9 Cf. Dieter Nerius, "Die Rolle der II. Orthographischen Konferenz (1901) in der Geschichte der deutschen Rechtschreibung," Zeitschrift für deutsche Philologie 119, no. 1 (2000): p. 31.
10 Cf. Thomas Serrier, Provinz Posen, Ostmark, Wielkopolska: Eine Grenzregion zwischen Deutschen und Polen 1848–1914 (Marburg: Herder Institut, 2005), p. 257 f.
11 Hanna Grzeszczuk-Bredel, "Das Gedächtnis des Raumes: Architektonisch-urbanistische Identifikationen in Posen nach dem Ersten Weltkrieg," in Der Umgang mit dem kulturellen Erbe in Deutschland und Polen im 20. Jahrhundert, ed. Andrea Langer (Warszawa: Instytut Sztuki PAN, 2004), p. 99 [translated by author].
12 Cf. ibid., p. 94–98.
13 Cf. Zygmunt Zaleski, Nazwy Ulic w Poznaniu z planem Wielkiego Poznania (Poznań, 1926), p. 11 f.
14 Cf. A. Jelonek, Dokumentacja Geograficzna Zeszyt Nr 5: Liczba ludności miast i osiedli w Polsce w latach 1810–1955 (Warszawa, 1956), p. 29.
15 Cf. Małgorzata Stepko-Pape, "Die 'wartende Stadt.' Gdynia – Gotenhafen (1926–1945)" (PhD diss., Universität Tübingen, 2011), p. 14 ff.
16 Cf. ibid., p. 19.
17 Cf. Hawlitzky, "Reichspost und Verwaltung," Postarchiv Zeitschrift für das gesamte Post- und Fernmeldewesen. Abhandlungen A. Allgemeines, Postwesen und Verwaltung 72, no. 3 (June 1944): p. 102.

18 BArch R 138-I/201, Gaumuseum für westpreußische Geschichte, Abschrift Die Umbenennung der Stadt Gdingen 5.4.1943, [original date unknown, ca. September 1939] [translated by author].
19 Ibid [translated by author].
20 BArch R 138-I/201, Der Gauleiter und Reichsstatthalter in Danzig-Westpreußen an den Herrn Oberbürgermeister in Gotenhafen, Danzig 1. April 1943[translated by author]; Other dates can be found. For instance, Małgorzata Stepko-Pape's research names the dates 19, 20 and 21 September 1939 as other possibilities.
21 Gerhard Wolf, Ideologie und Herrschaftsrationalität: Nationalsozialistische Germanisierungspolitik in Polen (Hamburg: Hamburger Editionen, 2012), p. 123 [translated by author].
22 Cf. Stefan Dyroff, "Ortsnamen im Gebiet der Provinz Posen. Zwischen Tradition, Fremdheitsgefühl und Nationalisierung," in Wiedergewonnene Geschichte: zur Aneignung von Vergangenheit in den Zwischenräumen Mitteleuropas, ed. Peter Oliver Loew, Christian Pletzing and Thomas Serrier (Wiesbaden: Harrassowitz, 2006), p. 296.
23 Cf. Maria Wagińska-Marzec, "Die Festlegung der Ortsnamen in den polnischen West- und Nordgebieten," in Das deutsche Kulturerbe in den polnischen West- und Nordgebieten, ed. Zbigniew Mazur (Wiesbaden: Harrassowitz 2003), p. 186.
24 E.g. "Der Direktor des Präsidialbüros des Ministerrats J. Żuniak an die Minister: Runderlaß Nr. 33 in der Angelegenheit der Beseitigung deutscher Aufschriften, 19. Juni 1945," in Die Deutschen östlich von Oder und Neiße 1945–1950: Dokumente aus polnischen Archiven Band 1, ed. Hans Lemberg and Wlodzimierz Borodziej (Marburg: Herder Institut, 2000), p. 158 f; Kerstin Hinrichsen, Die Erfindung der Ziemia Lubuska: Konstruktion und Aneignung einer polnischen Region 1945–1975 (Göttingen: V&R Unipress, 2017), p. 44.
25 Cf. Małgorzata Stepko-Pape, "Die 'wartende Stadt.' Gdynia – Gotenhafen (1926–1945)" (PhD diss., Universität Tübingen, 2011), p. 353.
26 Monitor Polski Nr A-51 Poz. 572, Zarządzenie Nr 62 prezesa Rady Ministrów z dnia 9 kwietnia 1953 r.

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6 Uncertain information and spatial objects

Examples from works on the HOUSe project and the European Historic Towns Atlas series

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Introduction

Putting objects in space – visualising spatial relations – has been the task of maps since they were conceived as a medium of communication.[1] Hence, the spatial dimension will usually be the first to look at in maps when people resort to them as tools for orientation in a part of "the real-world." But every map comes with a "time stamp," a date of its creation, and the image it conveys is by necessity one of space in the past. While the world gradually changes, this fact hampers their everyday use eventually. As time progresses and maps turn into "historic maps," they become a means to see the world as it was at a certain point in time – a historical source. Due to that temporal dimension, historic cartographic material, i.e. old maps and town plans, is of the greatest interest to researchers interested in the development of towns in general, and urban spaces in particular.[2] As a response, the European Historic Towns Atlas (hereinafter: HTA) series was created to provide researchers with access to that kind of material by editing it scholarly, i.e. redrawing it according to a standardised scheme.[3] In addition, many of the atlas publications synthesise all available information into an interpretation of the town's spatial growth in time by means of a commented growth-phases map. A genuine research result, it is basically a map (a thematic map), based on a map (a source edition map) derived from a map (a historic map).[4] Needless to say that uncertainty plays a role in this layered process, but it seems worthwhile to point out in some detail, in how far and in what ways this is the case.[5] We'll be doing so using examples from the forthcoming German HTA (Deutscher Historischer Städteatlas) of Magdeburg.

Digitisation has been an issue for the HTA from the 1990s.[6] These efforts have moved over time from taking first steps towards employing the "new media" in the form of CD-ROMs for publishing digital facsimiles of the print atlases to putting interactive towns atlas content online. While fulfilling several key functions such as filtering, searching, and layering information and reaching new audiences via the worldwide web, these forms of publication ultimately fall short of the initial goals set out for the HTA projects: to create basic research that can be re-used by

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scholars for their own analyses in historical urban research. In order to achieve this, e.g. to be able to use up-to-date digital tools, reusable, ideally FAIR research data must be created. Starting with the creation of geodata in Geographic Information Systems, the atlas projects set out towards this goal. It will be attained with the publication of the project geodata via a digital research data infrastructure.

One core problem to be solved in due course was that of the comparability of the data produced in projects scattered all over Europe. It is the main scientific goal of the HOUSe project to provide a framework for the comparative research approach. To fulfil this goal, the creation of a relational database with a conceptual and physical model built on a formal ontology of change with manifestations a relational spatio-temporal database with object-oriented data model was needed: the Urban HomeBase. Such kinds of databases facilitate the collection of geographic-historical information preserved on a mass scale,[7] but also require consistency not usually found in historical sources. Historians in search of information from the past about objects are using written primary sources in which some objects are described in more than one way. Gathering spatial data into databases, they have to deal with incompleteness, vagueness, uncertainty, and inaccuracy of information.[8]

Whether looking at historic maps or written evidence, everyone engaging in research concerning configurations of physical space in the past has to deal with uncertainty. We understand the term *uncertainty* not as a general observation that "our representations of reality are not exactly the same as reality itself," but as the *uncertainty* in assertions of given phenomena due to the lack of information or precision in the written or cartographic sources.[9] In our contribution, we want to share experiences from fields inherently connected with the HOUSe project, the historic towns atlases, and the Urban HomeBase, and draw attention to the uncertainty problem. After an explanation of the maps and sources, we add some methodological considerations that are the foundation for dealing with this issue, and then look at the main issues historians engaging with these sources encounter: spatial, temporal, and functional uncertainty. The aim of this chapter is to point out solutions in a descriptive way, which were implemented during work with the Urban HomeBase and are in use in the HTA series.

Maps and written sources

Town court books, registers of tax censuses, inventories, and documents with privileges – there are plenty of written source types in which elements of urban space from the past can be confirmed as existing. They provide historians with information about the existence of an object at a given time, its type, and function. However, superficiality of descriptions, origin from different chancelleries, different purposes behind the needs for source preparation, language differences, and finally, the preservation condition of the archives cause numerous interpretation problems in decision-making. Over time, the information from the sources may or may not have become more accurate. Fifteenth-century Old Warsaw buildings, like houses or barns, were identified mostly only by the names of their owners. More specific

buildings, such as churches, could be simply described as a "church," but when there were more churches in town, their patrocinia were given. In sixteenth-century town books, identification of a building was achieved using its neighbours' personal name and street name. If a building was of characteristic type and existed in the same place for centuries, finding its localisation may not cause any difficulties. It is more problematic with common buildings. Only in the 1780s numbers of plots were established in Warsaw and they remained quite stable until the first accurate cadastral plan of Warsaw was made by Lindley.[10] If a researcher can find information about the connection between a house or suburban palace and the plot number from the last two decades of the eighteenth century, then pointing out the location of that object is somewhat easier. Attention should also be paid to the differences in defining urban space depending on who wrote the source and who was its recipient. Sometimes it depended on the accuracy and willingness of a scribe, what kind of object emerges from the written record: whether it is an "ordinary" house, a tall tenement house, or a small shed.[11] Aligning information from written and cartographic sources was one of the main methodological decisions in the HOUSe project, while constructing the Urban HomeBase. The HTA series, however, focuses on cartographic material.

The most useful cartographic basis for reconstructing urban spaces in the past regarding the HTA series are early nineteenth-century survey maps. Such large-scale plot plans most commonly derived from cadastral surveys aiming at taxing landowners according to their possessions in real estate. As a general rule, they predate the changes which the Age of Industry ushered into the urban fabric and thus show the town layout much as it was in pre-modern times. However, the plot plans are not preserved in the archives in a condition that would make them usable for the average researcher. Drawn by hand to scales as large as 1:100 and 1:500, the individual plans show only parts of the town on large sheets of old paper. The main editorial work performed by the HTA cartographers consists in georeferencing the multitude of plans and vectorising them so that, in the atlases, the result can be printed as a unified survey map in the standardised scale of 1:2,500. At this scale it comes in manageable sizes, but still shows sufficient detail for urban landscape analysis.

The edited version of the survey map included in the HTA volume and the original map are vastly different – but this should not come as a surprise to anyone familiar with editorial work on historic sources of any kind.[12] Unless a source edition takes the most unscholarly form – i.e. that of a facsimile edition – even a medieval manuscript text will be transcribed using typographic characters, its spelling will be standardised, author's mistakes corrected, other source material and secondary literature cross-referenced, and comments added. Likewise, the map editor will go a long way to provide researchers with accessible, useful material. The redrawing of the historic survey maps is essentially the creation of a simplified version of the map content according to an accepted, albeit implicit model, so as to achieve a clearer picture and improve readability. While there is really no completely standardised methodology of source criticism for historic maps, cartographic source editions, like any others, have

their means to draw the user's attention to the fallacies and shortcomings of the maps in representing the historical reality.[13] Referencing the original sources is always the first step and a textual commentary will provide information on the sources and how they are being processed in the project. Uncertainty in the maps can also be mapped – either by delineating areas in which information was obviously lost or by using appropriate cartographic symbology for suggested interpretations, such as dotted lines to mark uncertainty. Ideally, by doing all of the above.

The redrawn nineteenth-century survey maps are the basis of the researcher's town plan analysis, i.e. the interpretation of the townscape with the aim of understanding the settlement's morpho-genesis.[14] Concerning the townscape, a well-known analogy to old manuscript texts comes to mind, that of a palimpsest: town plans usually preserve features from various times.[15] The urban fabric changed in many different ways over centuries, but the persistence of older features usually made sure that change was never evenly distributed or complete. A vegetable garden was quickly converted into a courtyard; the construction or demolition of a building took longer. Plot boundaries or the course of streets, once delimited, could prove very persistent because the rights and vested interests of neighbours and abutting owners were at stake. Hence, the plot structure, but also other layout features such as the street plan and land-use pattern as disclosed in the editorial process comprise tell-tale indicators concerning phases of urban growth and the location of objects such as town walls. An area made up of same-size plots in regular alignment may be interpreted as a "plan unit" that came into existence simultaneously at a certain point in time. The convergence and widening of streets in one point may be a hint at the former existence of a town gate which typically had an open space for traffic in front of the narrow passage through a defensive wall. However, the evidence of earlier maps and other depictions of towns, such as bird's-eye views, needs to be taken into account, just like archaeological sources. There is a lot of information processed in a map in order to identify areas of growth and attribute these to historical phases.

The way the map is styled, it uses the codified and standardised cartographic symbology, but still, there are instances of uncertainty which are covered up rather than pointed to by the visual codes maps use. The plot plan as a basis of the growth-phases map is the first problem in this respect. The plots are taken from the atlas base map 1:2500 created from original nineteenth century survey maps. While the persistence of urban plot patterns over centuries is in evidence in several towns, there is no certainty about it, unless corroborated by other sources.[16] In fact, the further back we want to trace urban development, the less reliable the plot structure becomes as evidence. Sometimes, telling street names such as New Street (*Neue Straße*) give away changes to the urban fabric, but in many instances there is a good chance (sic!) that a plot plan from the early nineteenth century captures features of the town around 1200. Due to the changes recorded by many archaeologists at about that time, everything beyond this point is pure guesswork and requires further substantiation. Still, for the goal of achieving spatial precision and

laying the foundation for the interpretation of urban development, the nineteenth century plot plan serves as a basis for mapping the growth-phases.

Methodological considerations: Reflections on uncertainty

When working with historical sources and capturing historical research data, we encounter uncertainty at many stages of the research process. Be it, as already described, ambiguous and/or fragmented historical survey maps, incomplete written sources, or a lack of temporal assignability of the sources. However, we do not only have to deal with uncertainty when working with historical sources, but also when modelling historical research data based on said sources. After all, these data must represent the uncertainty from the sources. It is important to keep in mind that the modelling of research data is a context-dependent form of representation. For different approaches and methods, the same data based on the same sources can take different forms. The ideas and approaches described in the remainder of this chapter refer to the contexts mentioned as examples in the text, the Urban Homebase and the HTAs.[17]

We focus on uncertainty regarding historical place data and geodata. At this point, it should be taken into account that information about places has different levels and meanings. Therefore, we distinguish between *space* and *place*. Both concepts are highly intertwined, but raise different issues when dealing with uncertain location information. A *space* is a location or a geographical point on the earth's surface. This can be described, for example, by longitude and latitude. On the other hand, people create *places* by attaching meaning to *spaces*. It is dynamic and subject to constant change, it has multiple "senses of *place,*" because different individuals associate it with different meanings over time.[18] Put simply, a *place* is a location plus meaning or function. In some cases, both aspects raise uncertainties; in others – only one of them. If one knows the concrete position of a building but not its exact function, information about the *place* is missing or uncertain. If, in contrast, we know what function a building served, but cannot locate it precisely, information about *space* is missing or uncertain.[19] By using this distinction between *place* and *space*, it is easier to define the terms geodata and historical place data for our use. We define geodata as data that are clearly linked to geometries in the geoinformation system, in other words, data that refer to *space*. By historical place data, in contrast, we mean data that supplements the geodata, e.g. by entering information on the function and use of a building that can be represented by a concrete geometry. This is how the concept of *place* is incorporated. The geodata are largely used in the geoinformation system. The historical place data can also appear in geoinformation systems, e.g. in the attribute table, but also in supplementary databases and other information systems. Of course, the historical place data can be used on their own, but in our use case, the combination of geodata and historical place data is crucial. To stay with our particular examples, dealing with uncertainty can therefore concern historians, cartographers, and (if involved) computer scientists and/or data stewards, who have to find a common way of dealing with the issue.

In this chapter, we highlight those aspects of uncertainty, which are part of working on historical primary written and cartographic sources with uncertain information and with handling imprecise data, in the form that they take place in our examples. We consider this chapter also as a discussion in a field of historical epistemology.[20] In the words of Jennifer Edmond: we would like to point out things we do not know precisely and why it is so.[21] Our vantage point is that of historians interested in digital cartography, digital history, and spatial humanities for possible future non-expert users of the HOUSe project results and HTA volumes. We do not strive to solve the problem of managing uncertainty once and for all. Also, we neither measure uncertain information[22] nor assign a level of uncertainty,[23] and because of the non-numerical (and non-measurable) characteristics of much of our data, we do not try to implement statistical methods of coping with uncertainties, like a fuzzy-set theory or fuzzy Bayesian inference.[24] In the part of this chapter dealing with the Urban Homebase we also do not get down to errors of measurement of distances or sizes, one of the main issues in GIScience methodology,[25] which hence also plays a major role in the creation of towns atlases.

In non-digital humanities contexts, uncertainty is most often described through the use of verbal expressions that themselves have a certain degree of vagueness, such as "mostly," "hardly any," "in the fourteenth century," or "before 1455." The use of digital methods force humanities scholars to rethink and approach uncertainty in a different manner, because digital representations of uncertain information need to be explicit.

But what constitutes uncertainty for the historian, in the first place? Most often it is incomplete or inconsistent knowledge, contradictory statements, or even the complete lack of information on an item. Uncertain information in sources can neither be neglected nor eliminated. Modelling uncertainty is a challenge, but ways must be found to do so in a formal way.[26] Still, what does uncertainty *mean*? The problem of imperfect datasets and imperfection in information leads some scholars to create taxonomies of uncertainty.[27] The notion and terminology varies depending on the author.[28] Terms like *uncertainty*, *fuzziness*, *vagueness*, *ambiguity*, and so on appear to be synonyms[29] when they are not: *uncertainty* is the lack or inaccuracy of knowledge about an object. *Fuzziness* pertains to objects that have features which are not clearly defined, like boundaries. Furthermore, *vagueness* stands for not precise or not detailed information about some objects or concepts that are written in sources or heard by someone. And *ambiguity*, which connects with imprecise information that could be connected to more than one specific object.[30]

We distinguish between three forms of uncertainty that we encounter in our work: spatial uncertainty, temporal uncertainty, and functional uncertainty. Often, when working with historical research data, we do not encounter just one separate form of uncertainty, but rather a closely interwoven combination of several forms of uncertainty, which can be present to varying degrees. For the sake of clarity, though, we introduce individual examples of the above-mentioned three forms of uncertainty. Before we get into the examples, we will give a brief explanation of the three forms of uncertainty mentioned above.

When we use the term spatial uncertainty, we mean uncertainty of *space*, i.e. uncertainties in the localisation or location of topographic objects. Spatial uncertainty can be caused by either an excess or a shortage of qualitative or quantitative spatial information.[31] A conceptual model of uncertainty in spatial data created by Peter Fisher, Alexis Comber, and Richard Wadsworth distinguishes between uncertainties caused by errors with well-defined objects and three types of uncertainties with imperfect definitions – vagueness and two kinds of ambiguity: discord or non-specificity.[32]

Temporal uncertainty refers to uncertainty in terms of time. We can also encounter this form in various places, be it the time of origin of a map that is not clear or the conclusion that a topographic object must have existed before a certain *terminus ante quem*. For both, ways of dealing must be found to model the data explicitly.

At last, we address the functional uncertainty or the uncertainty of *place*. At first glance, it may sound confusing to write about "uncertainty of *place*" when it comes to the function of topographical objects. Yet, the distinction between *space* and *place* explained above makes for a cogent argument. In our case, the information provided by historical place data primarily includes the function or usage of the topographic objects. When we speak of uncertainty of *place* in our field of application, we mean that – for a certain period of time or in general – it is not known or clear what function a topographical object had or what it was used for.

Uncertainty of space

The European historic towns atlas

It is a truism that the exactness of surveying work in the nineteenth century was affected by the seasonal changes and weather conditions as much as by the proximity of the next country alehouse. Be that as it may, with the measurements taken while surveying the urban landscape and then during the drawing of the paper maps in the surveyor's office based on the distances and angles recorded in the field, geometric imprecision started seeping into the map image.[33] Moreover, the ageing process affecting paper map originals stored in archives for a century or two again amplified the matter: during this time the large sheets of paper were prone to see irregular changes in the material – shrinkage most commonly – leading to a certain measure of distortion in the map image.[34] Depending on the equipment used, further distortion may arise in the scanning process which is part of the workflow of creating maps for a historic towns atlas. However, the resulting geometrical incorrectness in the mapped objects and the topological imprecision – the shift of map elements in their location relative to each other – is only slight and theoretically amended by georectification. For GIS, the scanned map image is then referenced according to real-world coordinates using corresponding anchor points found in both the map and the urban landscape (by using highly exact aerial photographs, precise modern survey data, or GPS coordinates).[35] The digital image is then "un-distorted," i.e. re-calculated to fit these points using one of a

choice of algorithms provided by the GIS software. While good working results can be achieved, oftentimes this process does not delete imprecision completely, because due to the transformations which the urban fabric has endured over time, the anchor points can hardly ever be distributed evenly across the entirety of a town (see Figure 6.1). Accordingly, the quality of the results varies within one town, specifically in the margins outside of the town walls where agricultural land was replaced by residential integuments.

Figure 6.1 Uneven distribution of anchor points in a georeferenced a historic survey map of Magdeburg (Stadtarchiv Magdeburg, Rep KS I/0691, No 35). Copyright: Oliver Rathmann, IStG Münster, with kind permission of Magdeburg City Archives.

The most time-consuming task of the HTA cartographer is the vectorisation of the map image, in effect the redrawing of all the map features that depict the townscape. Imprecision in the drawing process performed by human beings is inevitable, albeit more systematically consistent the more experience the cartographer has.[36]

Unfortunately, the historic survey maps themselves do not always relate complete and unambiguous information on the urban fabric, unlike earlier researchers had expected.[37] The problems of identifying in many cases even the most fundamental unit on which town plan analysis and urban morphology rely in historic survey maps, the urban plot, has been amply demonstrated even where the historic map survived in good condition.[38] This lack of evidence may, in fact, reflect the real situation, i.e. that property boundaries were not defined in such areas. Hence, no plot line could be drawn in the survey map and would then of course also be lacking in the edition. It is a problem frequently encountered, also in redrawing the survey maps for the historic towns atlas on Magdeburg.[39] While in some cases an ambiguous plot situation in cadastral maps can be clarified by the evidence of written cadastral records, this is not always the case. Uncertainty cannot be completely dispelled, and this is even more likely the case when the original drawing was altered subsequently.

Survey maps were usually in official use in various municipal and state agencies, sometimes over decades, during which their original content was obscured by damage and decay, or by adding new content so as to keep an up-to-date record of changes in the actual urban landscape or property situation (see Figure 6.2).[40] The most common of changes to the original map would be to amend it by using ink of a different colour, commonly by adding houses in times when densification occurred. When plots were divided for much the same reason, their original cadastral numbers were changed, usually into a fraction number. Such changes are visible and the original content remains easily traceable, but sometimes it has meticulously been erased by means of a blade. Cracks in the paper or flayed edges give the same effect, the result of inappropriate storage and careless handling.

In places where the original drawing is gone for good, one can attempt a reconstruction. If no unaltered copies survived elsewhere, this is most suitably achieved by turning to other cartographic products like topographical maps or town plans which have been drawn on the basis of the original survey map. These, however, are usually drawn to smaller scales so that the reconstruction may, again, entail a loss of spatial exactness.

Apart from the historical map originals and their treatment in the editorial process, spatial uncertainty also plays a role in the creation of the growth-phases map. There are two kinds of spatial information relayed in these interpretation maps: growth-phases and buildings with special uses, both of which may be subject to spatial uncertainty.

In the mapping process, the developmental phases themselves cannot not always be clearly delineated in space. For the earliest, pre- or proto-urban phases of town development, for example, archaeological finds of sunken huts or a textual source mentioning the unknown precursor of a church may be the first indicators of early medieval settlement cores. Yet, both forms of evidence pertain to a very

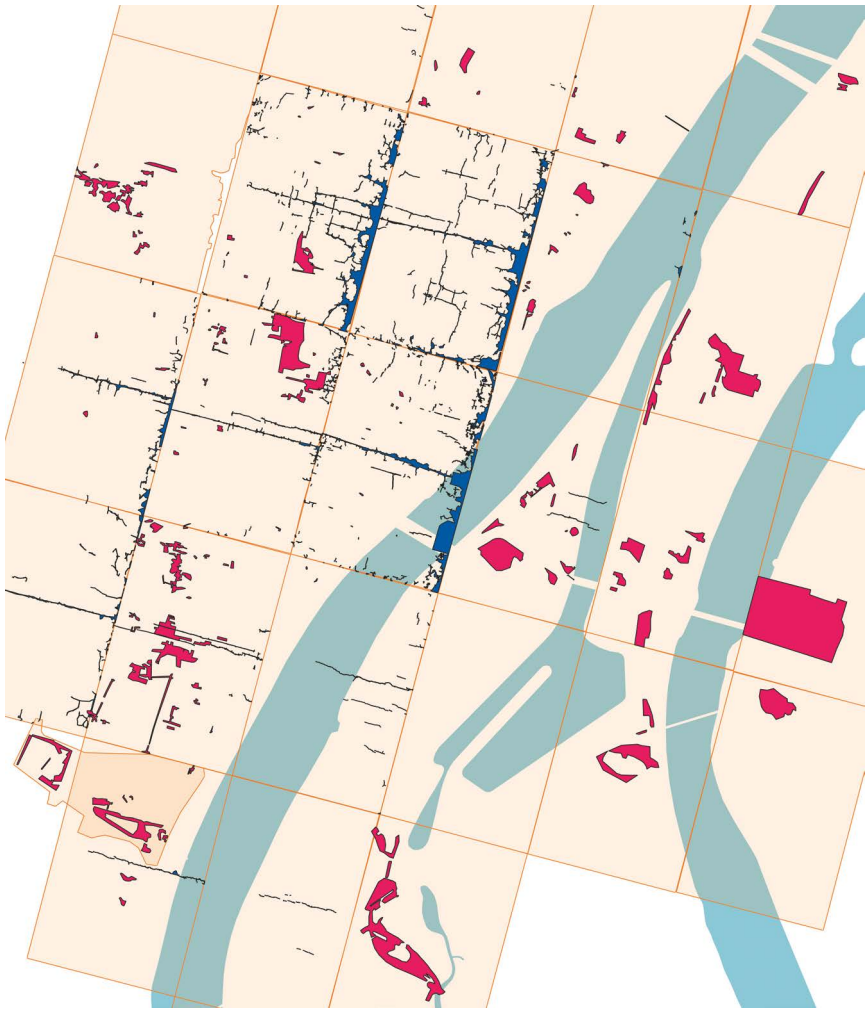

Figure 6.2 A Magdeburg example of the damages occurring in cartographic source material. Accidental cracks and tears depicted in blue, deliberate erasures depicted in red. Copyright: Oliver Rathmann, IStG Münster.

limited area: the excavation site or the church building. If it is to be expected that the settlement occupied more terrain than is accounted for in these sources, an attempt can be made to trace its boundaries in the nineteenth-century plot plan which may or may not have preserved hints to the earlier features. It is equally prudent to consciously ignore the temptation to align the proposed early medieval settlement with nineteenth-century town plan features and demonstrate uncertainty this way. Either way, although a plausible reconstruction of the settlement boundary may be the result, an archaeologist digging there at the next opportunity may be

disappointed to find neither ditch nor bank. While urban morphology has a methodological framework to put to work,[41] the further distant in the past, the less likely a feature is to have left traceable remains in the town layout as shown in the plot plan based on nineteenth-century survey maps.

This is just as true for buildings with special uses. Although slightly unwieldy, the term in fact correctly designates places like churches, hospitals, guild- or town halls, etc.; all such places with non-residential functions.[42] Many, but not all of these functional buildings are traceable in the nineteenth-century plot plans or have been excavated by archaeologists. Hence, one has to rely on older and usually less reliable forms of cartographic evidence, also town views and even follow hints in written sources for giving these functional buildings their location in space. By necessity, maps have to mark many such places as uncertain.

The growth-phases map wants to present a coherent interpretation with varying degrees of certainty. The risk of misunderstandings needs to be taken into account, but appropriate cartographic means ought to be employed to indicate uncertainties of interpretation: hachuring areas in the colour of the phases, blurring colours on the edges, or using dotted or dashed lines for delimiting proposed topographic boundaries where the evidence is less reliable. Although the cartographic tradition of thematic mapping is long, the language of maps does not always have the highly differentiated vocabulary needed to tell the complicated story of urban growth. A well-placed question mark may caution the map user. Inserting text into a map itself always brings about the risk of obscuring the map image, but is a viable means to signal to the map user that the analyst did not tread on firm ground. While any cartographic editor and urban morphologist will strive to prepare maps that communicate their meaning in the most unambiguous sense, uncertainty per se cannot be eliminated from these kinds of maps. And perhaps it doesn't need to be – when the map is accompanied by a text that explains the interpretation and draws attention to the variable basis of evidence. As with any interpretation in the humanities, the map's objectivity is to convey a sense of its subjectivity.

Urban HomeBase

As you might notice from the previous chapter of this chapter, the HTA series benefits from its long methodological tradition, which brings both solutions and various restraints in solving uncertainty problems. In the HOUSe project, we were using old maps of Warsaw from the eighteenth to twentieth centuries, too, but we did not have detailed plans from earlier phases of the town's history. For earlier periods, we needed to use written sources with localisations expressed in natural language. From there, even if the time period of the existence of a particular object is known, it is very hard (sometimes impossible) to pinpoint the space of the object. In 1650, Bogusław Leszczyński gave an area in Leszno (a small independent settlement with urban characteristics in the vicinity of Old Warsaw) to the Brothers Hospitallers of Saint John of God. The Hospitallers built a church, a monastery, and a hospital, but in 1666 they were relocated to

Old Warsaw's suburbs.[43] There is no cartographic representation of the Hospitaller Order's complex from that time, but there is information about its location in written sources. Adding this object to the database, one needs to address the certainty of spatial information. In the HOUSe project's workflow, we used three main types of description concerning a location's precision: "exact," "approximate," and "probable." There is a rather fine difference between "approximate" and "probable," which to some extent depends on the intuition of the author. An "approximate" location means the author knows (on the basis of his or her research) that the object was situated somewhere in that area, but could not find the exact space. "Probable," on the other hand, signals uncertainty in the interpretation of source information that connects a specific object with a specific area. In the case of the Hospitaller Order's complex in Leszno between 1650 and 1666, the author decided to designate the location type of that object as "approximate." The connection with plots bearing cadastral numbers 676–87 in the second half of the eighteenth century (and in nineteenth century: cadastral plans) in Leszno is certified by Zofia Rejman.[44] The problem with "probable" localisations can be exemplified by Old Warsaw's brickyard, known from sources from the first half of the sixteenth century onwards. It was located near the Vistula bank. Some of the roads and paths from the southern suburb's centre to the Vistula were identified by using a brickyard as a point of reference.[45] So the area of the brickyard is known, but the exact point is not. The author decided to enter the object into a database using exact coordinates, but also to supply information about its imprecise localisation according to the hypothesis of Krzysztof Mrozowski who has studied Old Warsaw's suburban space.[46]

Uncertainty of time

European historic towns atlas

Cadastral maps usually come with a lot of information, about the personnel involved with their creation, officials supervising the process, the location of the map in the context of the cadastral system, and of course the time during which it was made. There are, however, also cases such as those used for the Magdeburg atlas where there are few hints regarding the dating of the individual maps. These so-called *Feuerwerkerkarten* are clearly identifiable to be a single corpus as seen by their common alignment, scale, and sheet numbers.[47] The style of the maps, though, suggests that the corpus is made up of at least three separate groups covering different areas. Moreover, the cathedral area was obviously re-surveyed and has two map sheets in which the area depicted differently does not make matters any easier (see Figure 6.3). Moreover, the date that archivists suggest for the whole corpus, 1882, is only to be found in one of these maps, depicting the cathedral precinct. Is it, hence, justified to conclude that all the maps were created in a single effort in that same year? And what of the changes introduced by emendation later on? Relative chronology appears to be the last resort, unless a lengthy research process is to be undertaken.

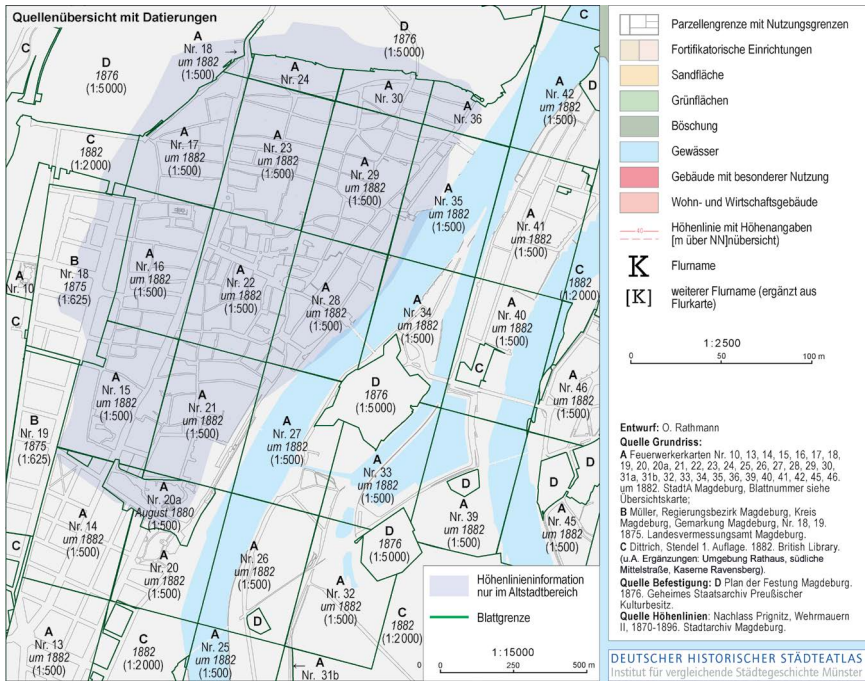

Figure 6.3 Overview map and legend of the German Historic Towns Atlas 1:2,500 base map for Magdeburg (unpublished work-in-progress). Copyright: Oliver Rathmann, IStG Münster.

A historic map, even when dated on the sheet itself to a single year, provides only a "snapshot" image of the townscape and does not tag each townscape feature depicted in it with a date of when it came into existence, or was demolished. Moreover, the snapshot metaphor taken from photography is misleading: old maps may even contain landmarks that were no longer there when the map was made.

The interpretation of urban growth in HTA, too, is riddled with uncertainties of dating: many forms of evidence are fairly precise spatially, but imprecise in the temporal dimension. Although archaeology does help with affixing dates to individual structures, more often than not archaeologists can only provide quite imprecise date ranges, in particular when the typology of ceramic forms is the basis for dating (e.g. "ninth to twelfth century"), or the radio-carbon method is used (e.g. "970 to 1030 AD"). Sometimes, the best dates archaeological excavation can yield are *terminus ante quem* or *terminus post quem*, i.e. a date before or after something has happened. In such cases, the most lamentable fact is not, of course, the imprecision of the dates delivered, but the *difference* in imprecision between archaeologists and historians: the dating intervals proposed by archaeologists hardly ever fit the urban historian's system of growth-phases who are trying to make sense of a town plan.

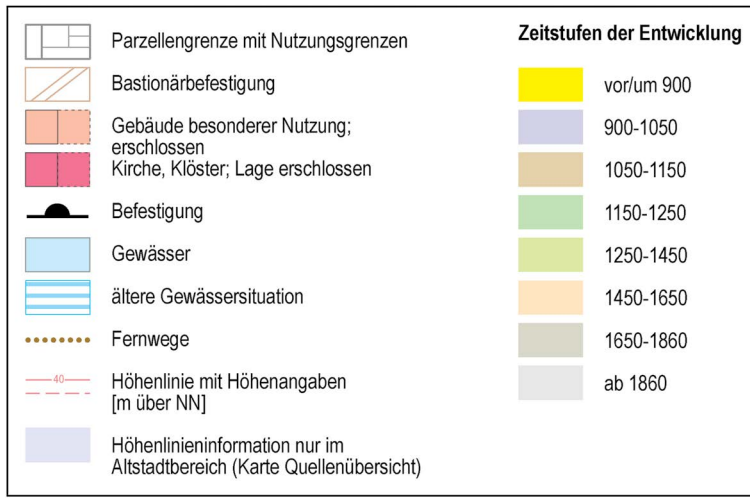

Figure 6.4 Example of the German Historic Towns Atlas' developmental phases map legend. Copyright: Oliver Rathmann, IStG Münster.

The standardised dating scheme of growth-phases used in the German HTA (*Deutscher Historischer Städteatlas*) has been devised to mirror the known historical phases of urban development as historians trace them in the area of the Holy Roman Empire (see Figure 6.4). [48]

The first or earliest of these phases used in the DHStA –"before/around 900 AD" – roughly correspond to the era of Carolingian rule and the Frankish Empire (751 to 919 AD). Apart from those areas with remains of Roman urbanity, proper towns are hardly to be found in that time, but certain early settlements such as hamlets and villages, often with early churches and mills, strongholds with earthwork fortifications, and trading emporia sometimes formed initial nuclei that may have developed into towns. The next phase – "900 to 1050 AD" – conforms more or less to the period of Ottonian rule in the Empire (919 to 1024 AD). In topographical terms, this phase usually saw more substantial settlements like privileged emporia, often near strongholds or monastic communities. These could form differentiated, polycentric conglomerates of settlement units in close vicinity to each other. Obviously with the rule of the Salian dynasty, including their successor Lothar von Süpplingenburg (1024 to 1125/37 AD) in the background, the next phase of the atlas scheme – "1050 to 1150 AD" – also brought about changes in settlement size and structure with initial town walls and perhaps acts of town planning, forming something more like what we today would accept as towns. Acts of town foundation, now of a model fully in bloom, and the granting of town privileges dominated the next phase – "1150 to 1250 AD." Again, the relation to the rule of a royal dynasty, the Staufer (1137 to 1250 AD), is obvious. The rest of the marks dividing the phases are set at regular intervals – "1250 to 1450 AD" and "1450 to 1650 AD" – and were set with regard to an increasing number of minor town foundations

("Minderstädte," Heinz Stoob),[49] in which many existing towns were in their full late-medieval bloom, and the Renaissance with the end of the Thirty-Years-War.

While kingship had an important part in founding and fostering settlements, proto-towns, and towns, the phases used to reconstruct the spatial development of towns fail to exactly match the time-span of certain kings' rules, partly because there were other players influencing this development. However, it is no coincidence that along the trajectory of the main historical dates, even numbers were chosen as more "artificial" boundaries. Hence, not "1648" but "1650" – which is as exact as a date, of course, but at the same time, the implicit message is: "round the middle of the seventeenth century, shortly after the Thirty-Years-War, something new happened in urban history, to last for about another 200 years." It is this kind of dating that will always be part of how historians talk about the past while trying to make sense of their sources and keep track of the chronology of events, simply due to the nature of the historical evidence. Thus, the legend of the map implies more certainty than there actually is.

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Data regarding time to be extracted from written sources usually relates to the existence and function of a phenomenon in the past, rather than the exact date of its creation, completion, or destruction.[50] Lack of accuracy connected with time (like "before 1427") and verbal, rather than numerical dating (like "the first half of the fourteenth century"), requires the historian to find ways for implementing such information into the data model of the database.[51] Various research projects have experimented with and found different ways to deal with temporal uncertainty. Cristina Vertan and Walther von Hahn represent uncertain temporal information in their ontology by specifying years as years-concepts, each of which is represented as an object in the ontology. They use datatype properties to distinguish between uncertain and exact dates, exactValues have the datatype string and aroundValues (and others) are defined as fuzzyDatatype.[52] Working in the field of non-standard lexical collections, the authors of DBÖ (Datenbank der bairischen Mundarten in Österreich/Database of Bavarian Dialects in Austria)[53] decided to assign to imprecise dates like "seventeenth c." a date in the middle of the century, i.e. 1650.[54]

Designing the UrbanOnto System, we had been aiming to deliver a tool useful for collecting both spatial data (longitude and latitude) and data from historical sources. We decided to create a table called `date_mappings`. In this table two columns are included, the first column has the name `imprecise_date`. There the datatype is "string," because many of the uncertain dating (temporal statements[55]) are described in a textual way as natural language (Polish, Latin etc.). The second column, called `precise_date`, has the datatype "integer." In that column the imprecise date is turned into a series of digits readable for the computer as an exact year. Only the imprecise dates "mapped" as precise dates in the table `date_mappings` may be used as values of `start_at` and `end_at` columns in other tables. Let us illustrate it with an example from Urban Homebase.

The issue of imprecise dating in our dataset is connected with scarcity of precise data about the very beginning of objects. More often than not, there are no written, nor archaeological, nor cartographic or graphic sources providing us with construction dates. The problem includes, among others, such important buildings as New Warsaw's town hall which was first mentioned in 1497 as a functioning building.[56] We may assume that it was not built exactly in that specific year, but neither is it impossible.[57] Regardless of whether we consider that the town hall was built earlier than 1497 or around that year, both dating are uncertain temporal statements.[58]

As it was explained before in the introduction to this book, the UrbanOnto ontology became a basis for a data model. This design obliges a researcher to provide at least one temporal orientation point: the beginning of the existence of the registered object or its end. The UrbanOnto ontology is an ontology of manifestations which brings an obligation to provide information on the timespan of a manifestation of a particular feature. After reaching a decision on how to date the town hall, researchers shall fill in that date in a column called `start_at` in Urban HomeBase's tables requiring temporal information (e.g., `topographic_object_location_manifestation`). But, as mentioned before, it is not possible to put imprecise or descriptive dating into fields which require a numerical value. This restriction has been introduced to the database to allow, i.e. access via GeoServer to spatial data collected in Urban HomeBase.[59] On the contrary, historians would not have to insert only a date without somehow annotating that date as imprecise. This is why columns `start_at` and `end_at` are more flexible than standard integer columns, i.e. to cater for the needs of historians. Values in those two columns must be either integers or values already present in the `imprecise_date` column in the `date_mappings` table. So, to put an imprecise date in the column `start_at` in the table `topographic_object_location_manifestation`, there is first of all a restriction to adding imprecise dating in the table `date_mappings`. When adding a new entry to the `date_mappings` table, in the `imprecise_date` column there is a possibility to add descriptive dating, such as "before 1497" or "ca. 1497." In the `precise_date` column users need to put the date in datatype integer. In our project, we decided to enter the year before in imprecise statements like "before 1497." So in the case of the town hall we have put the "1496" value in the `precise_date` column. Without any other information from written sources or from archaeological excavations about the starting point of the function of the object, we cannot be more precise. It is a little easier to map dates like "ca. 1497," because such a string of characters could be translated simply into the year 1497. Every value from the column `imprecise_date` has to be typed in an identical chain of strings in columns `start_at` and `end_at` in other tables with temporal aspects.

There are numerous ways of representing imprecise dating in the database. The more complicated it becomes, the more general temporal statements are provided, e.g. "the second half of the fifteenth century," which is also a possible dating of New Warsaw's town hall.[60] The description covers a timespan from 1451 to 1500. One might think that value "1475" is a viable compromise, as it is in the middle of the time span, but in fact registering the exact date would only gloss over the

uncertainty. Similar problems pose temporal statements like "15th c.". The timespan is even longer and covers 100 years from 1401 to 1500. In such cases, the entry of data in the Urban Homebase was also problematic. We decided to put the `precise_date` as 1401. As a result, the objects dated at "15th c." will be visible during the whole century, although we cannot determine precisely the end of their ontological identity.

The dates registered as `start_at` and `end_at` assume that the object began (which we understand as the beginning of object existence) in a particular year. It is more complicated with newly constructed buildings. It is obvious that objects were almost never created in one day.[61] Hence, the lowest level of granularity in the Urban HomeBase is a year. It is possible to create a new building in one calendar year, but this was not the case for many of the larger buildings in the past. We supposed that the end of construction work on an object was the date marking the beginning of its usage and thus established it as a place. Nevertheless, it is not that simple in every case.

The Dominican church of St. Hyacinth of Poland (Polish: św. Jacek Odrowąż) in Freta Street was built in the years 1604–1639. Around 1612, the presbytery with a sacristy and two chapels were erected, but the main nave of the church was under construction until 1639. However, masses were held at the construction site as early as 1606 in what was already built of the presbytery.[62] We do not know the architectural plans for the Dominican church and we do not know if the object completed in 1639 was identical with that "imagined" object from the beginning of the seventeenth century. Did the object need only a presbytery and a sacristy to be the church? The definition of church as an object from the OntoHGIS ontology used in UrbanOnto System states: "[a] church (in architecture) is a building used by a religious community to meet and listen to the word of God, for preaching, private prayers or to celebrate rituals."[63] In secondary sources there is a date pertaining to the consecration of the church by the local bishop. The presbytery with a sacristy and chapels fulfils the criteria of such a definition, but, unfortunately, we do not know how contemporaries would have seen the building and described it. In such cases, the author of the database entry has to decide to either enter the date "1606" or "1639" as a starting point for the church's function into the `topographic_object_type_manifestation` table of the Urban HomeBase.

Uncertainty of function and continuity

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The first indication of building uses, the function of buildings in the townscape, in the HTA projects may well derive from the nineteenth-century plot plan. In the case of Magdeburg, many buildings are highlighted in the maps with a deeper red colour to put them in this category. However, the specific uses these buildings have been put to are not necessarily those the historian interested in the earlier phases of town development may hope for: changes of function occurred as frequently as their

shift to different sites. This may have been caused by general historical developments, like the early nineteenth-century secularisation that had, above all, religious houses converted to army barracks, for example. By then, however, Magdeburg's Franciscan friary had already been closed. This happened in 1542 when the Protestant authorities converted it into the grammar school, in fact, *moved the function* of grammar school from its previous location to this place.

The multitude of changes in function and their being shifted from one site to another makes mapping extremely difficult. The more the urban fabric in general was subject to destruction, for example, the harder they are to trace. The most important ones for medieval urban development – churches and other religious institutions as well as town halls are usually mapped in the growth-phases maps at their original locations, but only rarely does the documentation cover change. Maps signal uncertainty concerning building locations to the user with dotted lines or hachured areas. But still, we map what we know, hardly what we do not know. At times, when well recorded, a second location may be added to the first one, but this is not a general rule. For the ecclesiastical institutions the information is usually more readily available than for others. The map legend gives a rough outline of a building's and institution's history, but this is never conclusive and in many cases leaves the question of the function and its continuity over time open.

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Working within the Urban HomeBase, we face the problem of identity and continuity within the urban area, either on a level of the whole town or on the level of a particular object, i.e. building or a street.[64] With historical topographical objects, uncertainty is created by the long gaps between their appearances in the written sources and a lack of knowledge about how stable an object remained in place and over time.[65] Integrating data about one object from different sources into one database may cause inconsistencies.[66] This problem can be illustrated briefly by an example. Was the suburban manor of Jan Tarło, voivode of Sandomierz (org. "Dwór jm.p. wojewody sędomirskiego"), that was mentioned in 1669 in Długa Street, the same object referred to in 1770 as a Tarło manor (org. "Dw. Tarłowski") in the same street?[67] Table 6.1 presents features of said object whose location can be determined only in relation to other objects from different temporal snapshots.

We can trace only one stable feature of the building, assuming we are discussing the same object, that is its residential (or housing) function. We do not know its precise location (i.e. coordinates), only that it was located in Długa Street.[68] For snapshots from 1743 and 1754, the relational localisation of the object was the same. There are also references in 1669 and ca. 1700 to the same owner of Perot (Perott). Two different ways were used to describe the type of object: sometimes it was referred to as a manor, sometimes as a palace. The most variable feature of the object was its name. In seventeenth- and eighteenth-century Warsaw, there were no official names of buildings, and the most common way to identify residential objects was to name them after their owners. If we assume that ownership is to be treated as a means of identification, it will constitute the feature of an object and

Table 6.1 Descriptions of Tarło's manor in the time span 1669–1770.

Year of information	*Name of the object*	*Type of the object*	*Location of the object*	*Function of the object*
1669	"Dwór jm.p. wojewody sędomirskiego"	manor	Street: Długa Relational: between Perot's garden and manor owned by Carmelites, in possession of Łętowski	residential
ca. 1700	"Pałac śp. wdy lubelskiego Tarła"	palace	Street: Szeroka Relational: between Perott and plot owned by Dominican Order female house from Góra	residential
1743	"Dwór Sapiezynski"	manor	Street: Długa Relational: between Skulski's manor and Bieliński's manor	residential
1754	"Pałac w. jm. p. starosty gorscynskiego"	palace	Street: Długa Relational: between Bieliński's manor and Sekulski's manor	residential
1770	"Dw. Tarłowski"	manor	Street: Długa Relational: Forestyer's tenement and Rusier's manor	residential

Source: Berdecka et al., *Źródła do dziejów warszawy*, pp. 235, 263, 365–6, 434–5, 493.

information about the possession of that specific building by members of Tarło family, which could form grounds for recognising the above-mentioned descriptions as a stable qualitative feature of the object.[69] However, the property register of 1743 mentions Sapieha's manor, which interrupts the chain of references to Tarło family members as owners of the object. As a result, the change in the name disrupted the identity criteria of the object.

In such specific cases, the domain expert needs to decide if values of Table 6.1 features relate to one particular building as a single, unstable object,[70] therefore the object within its various manifestations, or do we trace several different objects due to major differences in their types or names. Historical hermeneutics – with its epistemological tools – plays a huge role in this part of research.

Looking ahead

The discussion about uncertainty has a long tradition in literature of geography, information modelling, and digital history. Here, we added some insights from the point of view of historical urban studies, because historians have to deal with uncertain and incomplete sources and research data in their work on a regular basis. Many of the uncertain aspects of objects added to the Urban HomeBase were

left to the discretion of HOUSe project members–historians and cartographers. That is why they are rather simplified and described in a more narrative way.

To be clear, uncertainty is not necessarily a problem for research results: real-life phenomena are often uncertain in many different forms, and humanities approaches match this in ways that can be understood by human beings. In order to make use of the full analytical potential of GIS, though, information needs to be well-structured and explicit, and the more we rely on databases for storing information, the more so. However, in the cartographic source material, the interpretations we derive from it, and in the ways we communicate our interpretations, we frequently encounter and produce uncertainties.

It is not possible to resolve uncertainty completely and it should not be our goal to do so. Instead, ways must be found to formally model uncertainty by creating concepts that seem appropriate and feasible in the respective context. Models do not usually capture all aspects of what they are meant to represent, but focus on what is considered important in the context in which the model is used. Different types of uncertainty in different contexts require different approaches to modelling them. Uncertainty is an inherently subjective phenomenon; how uncertain data and sources are always depends on the context and the research questions. At which level of granularity does the information have to be in order to be able to answer the respective research questions?

We would like to briefly mention a few suggestions and ideas for the future of the above-mentioned projects: within the HiSMaComp project,[71] which reuses parts of UrbanOnto and builds on the experience of the HOUSe project, there is a lot of discussion about possibilities to model uncertainties in a sensible way for the project. This is not a complete list of potential approaches to dealing with uncertainty from the HiSMaComp project, but a first collection of ideas.

To begin with the uncertainty of *space*, one approach to dealing with spatial uncertainty is geosemantic contextualisation.[72] This combines the potential of geoinformation systems and semantic web technologies to be able to increase the complexity of the representation. By combining geodata with semantic historical place data, the topographic objects are always captured in two ways. Ideally, a geometry (geodata) and information on the function, usage, age of the object, etc., (historical place data) are available for a topographic object. Through the combination of both methods, one can still collect data in one way for the topographic object. This means that if, for example, only information on the existence and use of a topographic object is available from written sources, but no cartographic location is possible, the object can still be recorded. It is just as possible the other way round, i.e. if only a geometry is available because the object appears in a cartographic source but no further information is available.

One way to deal with temporal uncertainty is to work with time spans instead of points in time. An example of working with time intervals is the Extended Date Time Format (EDTF), an extension of ISO 8601, which is a worldwide standard for exchanging and communicating date and time-related data.[73] In this case, several columns are used to represent a date. This applies to both concrete and uncertain

dates and times. The concrete date of issue of a charter can be reproduced exactly with the help of two columns, but even a vague statement such as "middle of the fifteenth century" can be reproduced in a form that is machine-processable.

We have the most possibilities when dealing with uncertainty of *place* or functional uncertainty. With regard to spatial and temporal uncertainty, there are more approaches or even standards to fall back on or to be oriented towards. To deal with functional uncertainty, we currently have several options in mind, all of which have their advantages and disadvantages. One of many possibilities is, if several potential uses have been possible at the same time, to enter them with probability information. Though, this probability cannot be justified well and would be an interpretative act. Alternatively, one could simply enter several uses and then have all possibilities registered without working with probabilities. Furthermore, one could enter the number of source references for an information on the function of the topographic object. In this way, without working with probabilities, one can still enter which function/use has more evidence than others. The Urban HomeBase consists of a rough system of referencing registered data and information: a bibliographic table and columns in each table of manifestations allowing researchers to introduce detailed "footnote" to every entry in the database. This is not, however, a user friendly solution, therefore we are expecting to elaborate and find a suitable approach to modelling it within the HiSMaComp project in the near future.

In this initial attempt, we took a closer look at the HTA work and the Urban Homebase, we drew some attention to various levels on which uncertainty occurs in our work as a step towards implementing viable solutions to represent and work with uncertainty instead of eliminating and ignoring it. The most complex part of dealing with uncertainty is the modelling that explicitly represents uncertain data. Through modelling, uncertainty is neither lost nor resolved, it is just represented in a way enabling working with the data.

Notes

1 See: the Grand History of Cartography edited by J. B. Harley and D. Woodward: https://press.uchicago.edu/books/HOC/index.html

2 Useful introductions in English are: Jacinta Prunty, *Maps and map-making in local history*, Maynooth Research Guides for Irish Local History 7 (Dublin: Four Courts Press, 2004); Jacinta Prunty and Howard B. Clarke, *Reading the Maps: A Guide to the Irish Historic Towns Atlas* (Dublin: Royal Irish Academy in association with Blackrock Education Centre, 2011). There is abundant literature on the theme with variations according to national research traditions, differentiation between maps and town plans, chronological and typological divisions, and a variety of methodological approaches. This is not the place for such a bibliography.

3 On the European Historic Towns Atlas project, see: Wilfried Ehbrecht, ed., *Städteatlanten. Vier Jahrzehnte Atlasarbeit in Europa*, Städteforschung. Reihe A 80 (Köln-Weimar-Wien: Böhlau Verlag, 2013), esp. p. VII–XLIII.; Howard B. Clarke and Annegret Simms, eds., *Lords and Towns in Medieval Europe. The European Historic Towns Atlas Project* (Farnham-Burlington: Ashgate, 2015); Roman Czaja et al., eds., *Political functions of urban spaces and town types through the ages. Making use of the historic towns atlases in Europe* (Cracow: Wydział Humanistyczny Uniwersytetu Pedagogicznego; Toruń: Towarzystwo Naukowe; Vienna: Böchlau Verlag, Vandenhoeck

& Ruprecht, 2019) all with further references. See also: https://go.wwu.de/European-HTA, for a comprehensive list and an interactive distribution map of towns covered (annual updates).

4 On thematic maps, see: https://www.uni-muenster.de/Staedtegeschichte/portal/einfuehrung/karten/thematischekarten.html, for a brief overview; Mark Monmonier, *How to Lie with Maps*, 3rd ed. (Chicago-London: The University of Chicago Press, 2018); Erik Arnberger, *Thematische Kartographie. Mit einer Kurzeinführung über Automation in der thematischen Kartographie*, Das Geographische Seminar (Braunschweig: Westermann, 1977).

5 The following paragraphs focus on examples from the series *Deutscher Historischer Städteatlas* (German Historic Towns Atlas), including Magdeburg (to be published in 2024), see: https://www.uni-muenster.de/Staedtegeschichte/Deutscher_Historischer_Staedteatlas.html

6 Daniel Stracke, "The Digital Media Revolution – Historic Towns Atlases (HTAs) in a Data-Driven World," in *Towns as Living Spaces in (East)Central Europe: Static and Dynamic Aspects of Late Medieval Urban Communities*, eds. Elisabeth Gruber and Judit Majorossy, East Central and Eastern Europe in the Middle Ages, 450–1450 (Leiden, [forthcoming]).

7 Bogumił Szady, "Spatio-Temporal Databases as Research Tool in Historical Geography," *Geographia Polonica* 89, no. 3 (2016): p. 360, http://dx.doi.org/10.7163/GPol.0059

8 Szady, "Spatio-Temporal Databases," p. 362. The problem of "fitting" data from humanities to digital environments is well known also in other humanistic disciplines; Jennifer Edmond, "Strategies and Recommendations for the Management of Uncertainty in Research Tools and Environments for Digital History," *Informatics* 6, no. 3: 36 (2019): p. 7, https://doi.org/doi:10.3390/informatics6030036

9 Brandon Plewe, "The Nature of Uncertainty in Historical Geographic Information," *Transactions in GIS* 6, no. 4 (2002): pp. 431–2, 441, https://doi.org/doi:10.1111/1467-9671.00121

10 Katarzyna Słomska-Przech and Michał Słomski, "Urban Plot: Developing a Consistent Definition for Comparative Urban Studies," *Journal of Urban History* 50, no. 2 (2024): p. 425, https://doi.org/10.1177/00961442221089942

11 For more detailed remarks about the description of urban space and "imaginary cartographies," see: Daniel L. Smail, *Imaginary cartographies: Possession and Identity in the Late Medieval Marseille* (Itaka-London: Cornell University Press, 2000). For more on Old Warsaw at the end of Middle Ages, see: Krzysztof Mrozowski, *Przestrzeń i obywatele Starej Warszawy od schyłku XV wieku do 1569 roku* (Warszawa: Wydawnictwa Uniwersytetu Warszawskiego, 2020); Urszula Zachara-Związek, "Between Language and Space. Descriptions of the Medieval Townscape in Late Medieval Old Warsaw," *Historická geografie* 48, no. 2 (2022): pp. 95–112

12 See: e.g. Patrick Sahle, *Digitale Editionsformen. Zum Umgang mit der Überlieferung unter den Bedingungen des Medienwandels. Teil 1: Das typografische Erbe*, Schriften des Instituts für Dokumentologie und Editorik 7, (Norderstedt: BoD, 2013).

13 For more deliberations on the modelling of cartographic sources and "historical reality," see the chapter by Francesco Beretta in this book. See also: Tomasz Panecki, "Digital methods in cartographic source editing," *Digital Scholarship in the Humanities* 36, no. 3 (2021): pp. 682–697, https://doi.org/10.1093/llc/fqaa061; Roman Czaja and Radosław Golba, "Städteatlanten und GIS: die Edition der Katasterkarte der Stadt Thorn," in *Editionswissenschaftliches Kolloquium 2015. Die Geschichte im Bild*, eds. Helmut Flachenecker et. al. (Toruń: Towarzystwo Naukowe, 2016), pp. 49–66.

14 The most rigorous thinking on morpho-genetical methodologies has been pursued in the British school of urban morphology, see: Michael R.G. Conzen, *Thinking about Urban Form: Papers on Urban Morphology, 1932–1998*, ed. Michael P. Conzen (Oxford-Bern-Berlin: Peter Lang, 2004); see also: Keith D. Lilley, "Mapping the Medieval City: Plan

Analysis and Urban History," *Urban History* 27, no. 1 (2000): pp. 5–30; on the German tradition, see: Erich Keyser, "Des Stadtgrundriss Als Geschichtsquelle," in *Die Stadt des Mittelalters*, ed. Carl Haase, vol. 1 (Darmstadt: Wissenschaftliche Buchgesellschaft, 1969), pp. 364–76; Heinz Heineberg, "German geographical urban morphology in an international and interdisciplinary framework," *Urban Morphology* 11, no. 1 (2007): pp. 5–24; Dietrich Denecke and Gareth Shaw, eds., *Urban Historical Geography. Recent Progress in Britain and Germany* (Cambridge: Cambridge University Press, 1988).

15 Renate Banik-Schweitzer, "Die Stadt lesen wie ein Palimpsest – im Historischen Atlas der von Wien," *Jahrbuch des Vereins für die Geschichte der Stadt Wien* 52/53 (1996/1997): pp. 33–51.

16 See the remarkable continuity of streets in Stefan Mühlhofer, Thomas Schilp and Daniel Stracke, eds., *Dortmund*, Deutscher Historischer Städteatlas 5 (Münster: Ardey-Verlag, 2018): 6, fig. 7 and plates 4.1, 8.1; see Karsten Igel, ed., *Wandel der Stadt um 1200. Die bauliche und gesellschaftliche Transformation der Stadt im Hochmittelalter*, Materialhefte zur Archäologie in Baden-Württemberg 96 (Stuttgart: Theiss, 2013).

17 As Francesco Beretta in chapter "An ontology of geographical places and their spatiotemporal, social evolution in the context of an extension of the CIDOC CRM for the humanities and social sciences (SDHSS)" in this volume explained, there is a difference in modelling in ontology "real-world objects" and "representations of objects." This duality may not be easy to grasp and it causes several methodological problems. First and the most important is the approach to the source critique. Above, we gave examples of source critique leading based on the comparison and interpretation of various sources. The source critique rule applicable to the Historic Towns Atlas series has an interpretation of cadastral maps in its centre. Therefore, we start from the representation of urban space in the map, not from "real-world objects." Keeping this in mind, we would like to trace uncertainty in the series.

18 Doreen Massey, *Space, Place, and Gender,* (Minneapolis: University of Minnesota Press, 1994), pp. 1–16. http://www.jstor.org/stable/10.5749/j.cttttw2z.4

19 Yi-Fu Tuan, "Space and Place: Humanistic Perspective," in *Philosophy in Geography*, ed. Stephen Gale and Gunnar Olsson, Theory and Decision Library 20 (Dordrecht: Springer, 1979), https://doi.org/10.1007/978-94-009-9394-5_19, pp. 387–427 and Tim Cresswell, "Place: encountering geography as philosophy," *Geography* 93, no. 3 (2008): pp. 132–9.

20 Cf. Laurent Loison, "Forms of presentism in the history of science. Rethinking the project of historical epistemology", *Studies in History and Philosophy of Science Part A*, 60 (2016): pp. 29–37, https://doi.org/10.1016/j.shpsa.2016.09.002

21 Edmond, "Strategies and Recommendations," pp. 2, 5.

22 Cf. Michael F. Goodchild, "Imprecision and Spatial Uncertainty," in *Encyclopedia of GIS*, ed. Shashi Shekhar and Hui Xiong (Boston: Springer-Verlag, 2008), pp. 480–3.

23 As Markus Breier rightly points out, assigning levels of uncertainty of data from historical sources in most cases is an interpretation not based on measurements; Markus Breier, "Representing Spatial Uncertainty of Historical Places and Spaces in Interactive Maps," in *Power in Landscape. Geographic and Digital Approaches on Historical Research*, eds. Mihailo St. Popović et al. (Leipzig: Eudora-Verlag, 2019), pp. 170, 172.

24 Lotfi Asker Zadeh, "Fuzzy Sets," *Information and Control* 8 (1965): pp. 338–53, https://doi.org/doi:10.1016/S0019-9958(65)90241-X; Reinhard Viertl, "Foundations of Fuzzy Bayesian Inference," Journal of Uncertain Systems 2, no. 3 (2008): pp. 187–91. However, taking advantages of using fuzzy Bayesian inference is possible in research on historical data, see: e.g. José Luis Salinas et al., "A Fuzzy Bayesian Approach to Flood Frequency Estimation with Imprecise Historical Information," *Water Resources Research* 52, no. 9 (2016): pp. 6730–50, https://doi.org/doi:10.1002/2016WR019177

25 Michael F. Goodchild, "How Well Do We Really Know the World? Uncertainty in GIScience," *Journal of Spatial Information Science* 20 (2020): pp. 97–102.

26 Michael Piotrowski, "Accepting and Modeling Uncertainty," in *Die Modellierung des Zweifels – Schlüsselideen und -konzepte zur Graphbasierten Modellierung von Unsicherheiten*, eds. Andreas Kuczera, Thorsten Wübbena, and Thomas Kollatz, Zeitschrift Für Digitale Geisteswissenschaften. Sonderbände 4 (Wolfenbüttel, 2019).
27 Some of such taxonomies are briefly described by Renato Rocha Souza et al., "Towards A Taxonomy of Uncertainties: Analysing Sources of Spatio-Temporal Uncertainty on the Example of Non-Standard German Corpora," *Informatics* 6, no. 3 (2019): p. 34, https://doi.org/doi:10.3390/informatics6030034, where authors describe a taxonomy of uncertainty connected with information gathered in textual corpora. Further taxonomies are described in: Herbert Stachowiak, *Allgemeine Modelltheorie* (Wien et al.: Springer, 1973); Philippe Smets, "Imperfect information: Imprecision and uncertainty," in *Uncertainty management in information systems: From needs to solutions*, eds. Amihai Motro, and Philippe Smets (Boston, MA et al.: Kluwer Academic, 1997), pp. 225–254; and Michael Smithson, *Ignorance and uncertainty: Emerging paradigms* (New York, NY: Springer, 1989).
28 Plewe, "The Nature of Uncertainty," p. 434.
29 Breier, "Representing Spatial Uncertainty," p. 166.
30 Breier, "Representing Spatial Uncertainty," pp. 167–8, 171, see also: Manfred Thaller, "On vagueness and uncertainty in historical data," accessed: 9 November 2021, http://web.archive.org/web/20221110081154/https://ivorytower.hypotheses.org/88
31 Robert Jeansoulin et al., "Introduction: Uncertainty Issues in Spatial Information," in: *Methods for Handling Imperfect Spatial Information*, eds. Robert Jeansoulin et al., Studies in Fuzziness and Soft Computing 256 (Berlin-Heidelberg: Springer-Verlag, 2010), pp. 2–3.
32 Peter Fisher, Alexis Comber, and Richard Wadsworth, "Approaches to Uncertainty in Spatial Data," in: *Fundamentals of Spatial Data Quality*, eds. Rodolphe Devillers and Robert Jeansoulin, Geographical Information Systems Series (ISTE Ltd., 2006), pp. 44–5.
33 On cadastral surveys in general, see: Roger J.P. Kain and Elizabeth Baigent, *The cadastral map in the service of the state. A history of property mapping* (Chicago-London: The University of Chicago Press, 1992); for Westphalia: Gerald Kreucher, *Die Urkatasteraufnahme in Westfalen*, Veröffentlichungen des Landesarchivs Nordrhein-Westfalen 20 (Düsseldorf: Landesarchiv Nordrhein-Westfalen, 2008). In the comprehensive series "History of Cartography," Volume 5 on the nineteenth century is still in preparation, https://geography.wisc.edu/histcart/editors/
34 On the archival situation of old maps, see the bibliography at: https://www.archivschule.de/DE/service/bibliographien/auswahlbibliographie-karten-in-archiven.html#3
35 On GIS methods in general, see: Charles Warcup, *Von der Landkarte zum GIS. Eine Einführung in geografische Informationssysteme* (Norden-Halmstad: Points-Verlag, 2004). On GIS use in the HTA community, see also: Stracke, "The digital media," (forthcoming).
36 For a detailed description of the editorial process, see: Czaja and Golba, "Städteatlanten und GIS," pp. 49–66. In the German Historic Towns Atlas, editorial methods are commented on in the section "Quellenkritische Bemerkungen", see e.g.: Antje Schloms, Daniel Stracke and Helge Wittmann, *Mühlhausen/Th.*, Deutscher Historischer Städteatlas 6 (Münster: Ardey-Verlag, 2020), pp. 34–6.
37 For comments on the resulting debate, see: Peter Johanek, "Stadtgründung und Stadtwerdung im Blick der Stadtgeschichtsforschung," in: *Stadtgründung und Stadtwerdung. Beiträge von Archäologie und Stadtgeschichtsforschung*, ed. Ferdinand Opll, Beiträge zur Geschichte der Städte Mitteleuropas 22 (Linz: Österreichischer Arbeitskreis für Stadtgeschichtsforschung, 2011), esp. pp. 156 ff.
38 Cf. Słomska-Przech and Słomski, "Urban Plot."
39 Deutscher Historischer Städteatlas – Nr. 7: Magdeburg (in preparation), cf. https://www.uni-muenster.de/Staedtegeschichte/Forschung/Deutscher_Historischer_Staedteatlas.html

40 See: e.g. Czaja and Golba, "Städteatlanten und GIS," p. 57, fig. 3, with later addition of buildings and changes of names in red ink.
41 See: Martin Möhle, "Stadtplananalyse. Eine historisch-methodische Einführung," *Zeitschrift für schweizerische Archäologie und Kunstgeschichte* 75, no. 2/3 (2018): pp. 163–184, with references to all major schools of Urban Morphology.
42 The term "public buildings" would be more intuitive, but anachronistic and less accurate since many such building types and institutions would not be open to the general public at all, e.g. female monasteries.
43 Iwona Pietrzkiewicz, *Miser res sacra. Bonifratrzy w dawnej Rzeczypospolitej* (Kraków: Bikstudio Krzysztof Marek Szwaczka - Drukarnia Pijarów, 2009), pp. 64–5.
44 Zofia Rejman, "Jurydyka Leszno w czasach Stanisława Augusta Poniatowskiego. Część I," *Rocznik Warszawski* 18 (1985): p. 81.
45 Mrozowski, *Przestrzeń i obywatele*, pp. 103–5.
46 Mrozowski, *Przestrzeń i obywatele*, p. 107.
47 Katarzyna Słomska-Przech and Keith Lilley are discussing comparisons of maps of Warsaw and Ordnance Survey maps from Ireland in their chapter of this book, giving more observations on methodology of work with cartographic sources.
48 See: Deutscher Historischer Städteatlas, eds. Wilfried Ehbrecht, Jürgen Lafrenz, Peter Johanek & Thomas Tippach, vol. 1–6, Münster 2006 ff. Plate 4 (Tafel 4) is the regular place for the growth-phases map.
49 Heinz Stoob, "Minderstädte. Formen der Stadtentstehung im Spätmittelalter," *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte* 46, no. 1 (1959): pp. 1–28.
50 Szady, "Spatio-Temporal Databases," p. 366.
51 Breier, "Representing Spatial Uncertainty," p. 170.
52 Cristina Vertan and Walther von Hahn, "Modelling Linguistic Vagueness and Uncertainty in Historical Texts," in *Proceedings of the Workshop on Language Technology for Digital Historical Archives in Conjunction with RANLP-2019*, ed. Cristina Vertan, Petya Osenova, and Dimitar Iliev (Varna: INCOMA Ltd., 2019), p. 37.
53 https://dboema.acdh.oeaw.ac.at/dboe/
54 Rocha Souza et al., "Towards A Taxonomy," p. 21.
55 Kamil Matoušek, Martin Falc, and Zdeněk Kouba, „Extending Temporal Ontology with Uncertain Historical Time", *Computing and Informatics* 26 (2007): p. 247.
56 Andrzej Sołtan, "Miasto Nowa Warszawa w XV–XVII wieku," *Kronika Warszawy*, no. 1 (140) (2009): p. 8.
57 Archaeological excavations held at 1950's did not answer question about possible starting point or period of functioning the object; Włodzimierz Pela, "Badania archeologiczno-architektoniczne siedzib władz dawnej Warszawy. Kamienice wójtowskie oraz ratusze - staro- i nowomiejski," *Rocznik Warszawski* 36 (2008): p. 126
58 There are two main hypotheses about dating the New Warsaw's town hall. Aleksandra Świechowska suggested, that the town hall was built "probably after the half of the fifteenth century"; see: Aleksandra Świechowska, "Początki osadnictwa na terenie Nowego Miasta," in *Szkice Nowomiejskie*, ed. Olgierd Puciata et al. (Warszawa: Arkady, 1961), p. 19. On the other hand, Anna Berdecka supposed the town hall was erected later, at the end of fifteenth century "around 1497"; see: Anna Berdecka, "Rozwój Nowej Warszawy w XV i XVI wieku," in *Szkice Nowomiejskie*, p. 49. It was constructed in the south-eastern part of the New Warsaw's market square and was destroyed in 1657. After destruction it was rebuilt in another place of square; see: Pela, "Badania archeologiczno-architektoniczne," 126. More recently, Włodzimierz Pela mentioned presumable fire destruction of town hall in 1471; see: Włodzimierz Pela, *Historia badań archeologicznych i architektonicznych dawnej Warszawy*, Archeologia Dawnej Warszawy 2 (Warszawa: Muzeum Historyczne m.st. Warszawy, 2013), p. 183.
59 For further information, see: GeoServer. 2023. "GeoServer 2.23-SNAPSHOT User Manual," accessed: 5 July 2023, https://docs.geoserver.org/stable/en/user/

60 Świechowska, "Początki osadnictwa," p. 19; Pela, "Badania archeologiczno-architektoniczne," p. 126.
61 Thaller, "On Vagueness,".
62 Julian Bartoszewicz, *Kościoły warszawskie rzymsko-katolickie opisane pod względem historycznym* (Warszawa: Drukarnia S. Orgelbranda, 1855), pp. 173–4; Jolanta Putkowska, *Architektura Warszawy XVII wieku* (Warszawa: Państwowe Wydawnictwo Naukowe, 1991), p. 199.
63 https://onto.kul.pl/ontohgis/settlement_type_120, accessed: 24 October 2022.
64 Regarding the search for urban objects continuity criteria, see the objectivities concerned about identity of historical localities proposed by Paweł Garbacz, Bogumił Szady, and Agnieszka Ławrynowicz, "Identity of Historical Localities in Information Systems," *Applied Ontology* 16, no. 1 (2021): pp. 55–86, https://doi.org/10.3233/AO-200235
65 Grzegorz Myrda, Bogumił Szady, and Agnieszka Ławrynowicz, "Modeling and Presenting Incomplete and Uncertain Data on Historical Settlement Units," *Transactions in GIS* 24, no. 2 (2020): p. 361, https://doi.org/10.1111/tgis.12609; Paweł Garbacz, "On Qualitatively Unstable Objects," *CEUR Workshop Proceedings*, no. 2050 (2017): p. 2.
66 Garbacz, "On Qualitatively Unstable Objects," p. 5. See: similar statements for databases gathering measurements from different sources made with different measurement tools in Goodchild, "How Well Do We Really Know," p. 100.
67 Anna Berdecka et al., eds., *Źródła do dziejów Warszawy. Rejestry podatkowe i taryfy nieruchomości 1510–1770*, Materiały do dziejów miast polskich (Warszawa: Państwowe Wydawnictwo Naukowe, 1963), pp. 235, 493.
68 Although in ca. 1700, the source used the name "Szeroka Street."
69 Unless the house was demolished and rebuilt between the time periods.
70 Garbacz, "On Qualitatively Unstable Objects," p. 3.
71 The full title is: "Historical survey maps and the comparative study of the functionality and morphology of urban space. Standardisation – Digital processing – Research (HiSMaComp)." For project information, see: https://hismacomp.hypotheses.org/
72 This approach was presented as a poster at the Digital History Conference in Berlin in May 2023, see: Anna-Lena Schumacher, Tobias Runkel, Daniel Stracke. 2023. "Geosemantische Kontextualisierung urbaner Räume," https://doi.org/10.5281/zenodo.7946887
73 "Extended Date/Time Format (EDTF) Specification," The Library of Congress, last modified: 4 February 2019, https://www.loc.gov/standards/datetime/

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Part III

Mapping objects in urban space

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7 Polish Database of Topographic Objects 1:10,000 as a basis for building the formal domain Historical Ontology of Urban Spaces

Construction, verification, validation

Katarzyna Słomska-Przech and Wiesława Duży

Introduction

Project Historical Ontology of Urban Spaces (HOUSe) aims at developing a domain ontology representing concepts related to historical towns. Like Gómez-Pérez, we see ontologies as "platforms that enable the sharing and reuse of knowledge by establishing common vocabularies and semantic interpretations of terms."[1] The HOUSe ontology[2] (also referred to as "UrbanOnto ontology") was used to develop the database model for collecting data about objects in towns. The upper-level ontology for the UrbanOnto ontology is CIDOM-CRM.[3] The UrbanOnto ontology benefits also from the model of the official Polish Database of Topographic Objects (BDOT)[4] and OntoHGIS[5] ontology developed by the team of Szady.

The first aim of this chapter is to (1) describe the development of the UrbanOnto ontology and therefore verify its quality in terms of intrinsic properties. The second goal is to (2) validate the constructed ontology, through considering which of the models – BDOT or UrbanOnto (as a whole) – is more applicable to work with old town maps. In this step, we want to undertake the verification of the hypothesis that BDOT is more fitting than UrbanOnto for modelling historical urban space, while UrbanOnto ontology is suitable for mapping to the reality accessible through historical sources, but problems could arise if the goal were to explore another model through an ontology.[6]

Thus, in general, the second aim is to validate the utility of the ontology for future work. Hence, in our paper we want to refer to the two-track method of evaluation by verification and validation proposed by Suen et al. (1990) and described in reference to ontologies e.g. by Lovrencic and Cubrilo,[7] and Gómez-Pérez.[8]

It is necessary to mention that in the research performed to date, the validation phase is present in spatial humanities; however, it is not a standard element of the research procedure. We find clear, explicit information about the validation phase in the research by Pawel Garbacz and Robert Trypuz,[9] and Ewa Kowalczuk and Agnieszka Ławrynowicz.[10] Validation is recommended, however, it is not yet part of the reported research. Bogumił Szady and Agnieszka Ławrynowicz only

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declare some validation-like elements planned for future research.[11] In a different publication, Szady argues that "[t]he above-discussed considerations are of a tentative character and thus can only delineate the challenges of applying spatio-temporal databases to historical research."[12] Related research with a validation procedure does exist, but is limited to observations of case studies and building identity criteria upon these observations[13] or without an explicitly declared validation element.[14] We focus here on research conducted around OntoHGIS ontology building, one of the most important domain ontologies preceding UrbanOnto. However, a similar situation may be observed regarding CIDOC CRM, an upper-level ontology for both OntoHGIS and UrbanOnto,[15] even if the majority of researchers use CIDOC CRM as a tool for validating their mappings and data quality assessment.[16]

Construction of UrbanOnto on the basis of OntoHGIS and BDOT

The UrbanOnto ontology benefits from the OntoHGIS ontology – a domain ontology collecting information on historical administrative units.[17] The OntoHGIS ontology is the first ontology built at the Department of Historical Atlas (Tadeusz Manteuffel Institute of History of the Polish Academy of Sciences, also referred to as IH PAN). The process of designing it had been preceded by an extended analysis of the state of the art, including assessment of various domain ontologies.[18] This study confirmed that it was necessary to elaborate a new formal domain ontology in the IH PAN. The OntoHGIS ontology models both administrative units and settlement types, focusing on their manifestations in time for registering any change influencing their ontological status and identity. It is worth mentioning that both, OntoHGIS and UrbanOnto, are formal engineering ontologies of manifestations. It means that according to this ontology, all entities are divided into variable and non-variable entities. Manifestations of variable entities are among non-variable entities.[19] This particular feature influenced not only how knowledge is organised in OntoHGIS and UrbanOnto, but later also shaped the structure of UrbanHome Base, a database built as part of the HOUSe project. For our considerations here, it is also important to explain that the OntoHGIS ontology consists of definitions of: 1) types of settlements and localities, and 2) administrative units. Definitions of types of settlements and localities is a general expression allowing us to operationalise various entities recognised as human settlements and localities. It also, however, includes definitions of entities which were defined both as settlements and/or as buildings. Definitions of settlement types in the OntoHGIS also include definitions of functions. These two elements decided on including OntoHGIS to the UrbanOnto ontology to meet Linked Open Data recommendation on connecting various datasets and work with standards.[20] A consequence of this decision is that (among others, i.e. presence of the administrative units component): 1) for complete usability both UrbanOnto and OntoHGIS ontologies are essential, as some definitions are

included in the OntoHGIS ontology and only linked to the UrbanOnto ontology. Let us provide some examples:

1 Among buildings:
   - **"church"** had been modelled in OntoHGIS and therefore UrbanOnto uses the existing definition. "Church" (IRI https://onto.kul.pl/ontohgis/settlement_type_120) had been imported to the UrbanOnto as a part of OntoHGIS ontology. Class "church" is a subclass of the "building" class included in the OntoHGIS. The "buildings" class also exists in BDOT, enriched by a subclass of "buildings intended for religious worship and religious activities" with several more detailed subclasses. Both these classes, i.e. "building" and "buildings," are subclasses of "SpaceTime Volume" and "Persistent Item" modelled in CIDOC CRM;
   - **"stable"** had been modelled directly in UrbanOnto. Class "stable" (IRI https://purl.org/urbanonto/object_type_4b313ab4-5059-46a7-b62e-000c7f813666) is a specific type (in OWL it is a SubClass of) of farm buildings from BDOT structure, which is a subclass of "building", and upper-level classes of it are as mentioned above.
2 Among functions:
   - **"Accommodation function"** (IRI https://onto.kul.pl/ontohgis/function14) which is modelled as an individual function in OntoHGIS ontology;
   - **"Entertainment function"** (IRI https://purl.org/urbanonto/function20) which is modelled as an individual function in UrbanOnto ontology.

All functions from both OntoHGIS and UrbanOnto are direct instances of the "function" class from the Basic Formal Ontology (IRI http://purl.obolibrary.org/obo/BFO_0000034).

As mentioned above, types of settlements and administrative units defined in the OntoHGIS ontology are not sufficient to meet the requirements of tasks and research questions of the HOUSe project. The aim behind the HOUSe project was to build an ontology of urban space understood as a system of entities/classes observed inside the town or city over centuries. Therefore, UrbanOnto is also based on the modern model of a database – that is the Database of Topographic Objects (in Polish: *Baza Danych Obiektów Topograficznych*, also referred to as BDOT) used officially in Poland.[21] We decided to choose the BDOT model because it has already proved useful in earlier historical research. Panecki[22] used the BDOT model to develop the concept of the database structure of historical topographic objects (BDHOT). Based on symbols used in old maps, he completed the model with objects that existed in space in the past.

Proceeding in a similar manner, researchers participating in the HOUSe project supplemented the list of terms from the modern database with types of objects existing in the towns in the past based on, *inter alia*, information from sources, maps from Historic Town Atlas series, and their expertise. We pointed to an assumption

that an ontology-based model may prove helpful in standardising geodata and objects observed in the HTA series.[23]

Verification – A scheme for developing a consistent list of object types from the UrbanOnto, OntoHGIS, and BDOT ontologies

It should be noted that in this section the aim is to evaluate the quality of the ontology (product), but not its usefulness. According to Gómez-Pérez,[24] while adopting system verification rules for ontology purposes – such aspects as correctness, completeness, consistency, and coherence of ontology definitions and conciseness – one should take into account expandability and sensitivity of the system.

Definition correctness, completeness, and consistency had been verified at the very beginning of the ontology-building process. We adopted the following procedure:

1 We selected a definition structure common for all entities/objects introduced to the ontology.
2 We selected definition syntax and semantics.
3 We decided on definition pragmatics, but placed them in the context provided by other definitions and their relations.
4 We wrote a script for testing definitions imported to pre-designed ontology scheme upon entry.
5 We analysed a report on the initial import and corrections introduced to all definitions by domain experts.
6 We repeated definition import with the same script.
7 We closed the definition import.

It is worth explaining that the above-mentioned decisions about definition structure, syntax, semantics, and pragmatics were taken alongside engineering ontology design. So as to facilitate the process for domain experts, who are not experts in building domain ontologies, it was necessary to design a matrix enabling historians to introduce their work for further elaboration by our IT expert. The whole UrbanOnto formal ontology has been built in the Protege application with OWL syntax.[25] It is also worth mentioning here that steps no. 5 and 6 from the above list were repeated until the script threw back zero errors. The first iteration of the test revealed 62 possible errors,[26] broken down into the groups listed below:

1 No Polish comment (understood as a short classical definition expressed in a natural language) in the selected definition.
2 No proper function determined in definition matrix.
3 Invalid relation to BDOT ontology.
4 Invalid relation to proper function (introducing non-existing function).
5 Empty entry for BDOT object.

6 Object type with particular label already existing in ontology.
7 Invalid legal status in selected definition.
8 Ill-formed sheet, in other words invalid structure of definition (understood as invalid number of rows in the workbook).

The following section describes the manual harmonisation process to verify the UrbanOnto ontology and the problems encountered during its implementation. In order to verify the ontology, a table with object types was prepared and the definitions were checked using the Protege software. The harmonisation procedure consisted in (I) developing one sheet with object types from the UrbanOnto and BDOT ontologies, (II) combining twin types of objects from both ontologies in a sheet into one record, (III) supplementing the classification used in the BDOT ontology for objects from the UrbanOnto ontology, (IV) complementing object Internationalized Resource Identifiers (IRI) (Figure 7.1). The object types from the BDOT model belong to object categories and classes. This hierarchy has been retained in the object types developed within the UrbanOnto ontology, classifying the types from UrbanOnto according to the BDOT schema and linking them to objects, classes, or categories of object classes. In selected situations, it turned out to be necessary to reverse the order – selected objects, found by domain experts, e.g. in the HTA series did not allow for an unambiguous classification. It was also necessary to verify and update IRI of all OntoHGIS ontology elements embedded in the UrbanOnto. The reason for this was the unsolvable problem with the PURL server. Syntax of IRIs in OntoHGIS initially was built on the PURLs (similar to IRIs in UrbanOnto), which are persistent URLs. Unfortunately, due to an unknown bug these were not available for a longer period of time and creators of the OntoHGIS decided to migrate

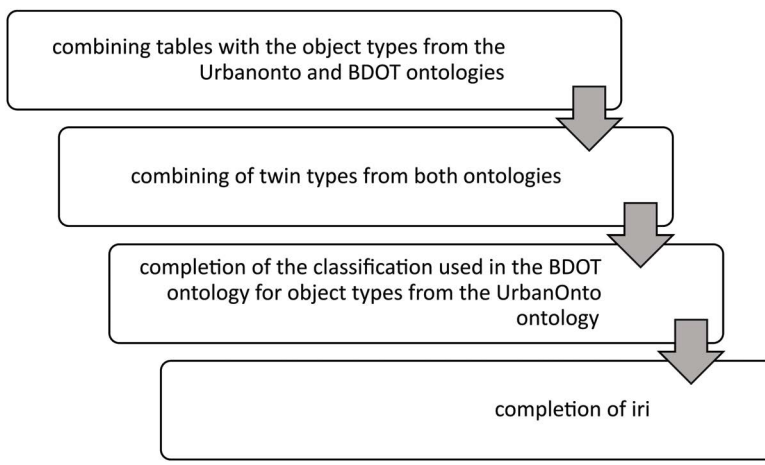

Figure 7.1 Scheme of developing a consistent list of types from the UrbanOnto, OntoHGIS, and BDOT ontologies.

whole OntoHGIS ontology to a local university server. It caused a change in IRI prefixes: from "http://purl.org/ontohgis#" to "https://onto.kul.pl/ontohgis/." As a result, it was necessary to carry out the harmonization process summarized below. This made it possible to detect a series of bugs and correct them in the next version of the UrbanOnto ontology.[27]

Objects from the UrbanOnto ontology are not as easily classifiable as the objects themselves in BDOT, because it is all nested in a higher-order ontology, CIDOC CRM, and also related to the OntoHGIS ontology. If we are interested only in the object group constituted by types of BDOT objects, it is possible to analyse their position in the hierarchy (classification from the BDOT model). However, in the case of the entire UrbanOnto ontology, it is infeasible to apply a uniform classification and hierarchy, and the types of objects should be considered separately and in relation to other types of objects. The ten following problems were identified in the process of verification.

P.1. In some cases, due to the characteristic features of the historical object type, it was necessary to develop a definition of this object within the UrbanOnto ontology, even if the type previously existed in the BDOT structure. These are the cases of the so-called twin types, i.e. having the same label and meaning (e.g. "embankment," "bridge," "park," "stairs"). Then these types should have a completed relation "owl: equivalentClass <IRI>." While working on the harmonisation, it turned out that there were gaps in the ontology, e.g. objects of the "parking space" type were not equivalent to each other.

P.2. Object merger could not be performed for all object types with the same name. Facilities connected with toll collection ("toll collection station" and "toll collection point") should not be combined into nor equated to one type of object, as was the case in the first version of the ontology. In the BDOT ontology, "toll collection point," connected with transport, strictly referred to toll stations that can be found on modern roads ("[r]oofed area with gates, cash desks and roadways separated from each other on a motorway or other toll road, created to collect tolls for a given road section"[28]), while in the UrbanOnto ontology a similar type adopted a broader meaning ("a building, usually small, where travellers pay for road use"[29]). We therefore modelled a "toll collection station" class in addition to a BDOT "toll collection point" class.

P.3. In the harmonisation process, we could also observe problems resulting from the ambiguity/imprecision of the classification and hierarchy introduced in BDOT and developed in UrbanOnto. An interesting type of object is "square." Usually, when there are two twin types (e.g. two types of "bridge"), they were in the same category and class. For the type "square," this was not the case. One of the "square" type objects is a type from the "land cover" (BDOT) category. The second type of "square" is classified as "E25 Man-Made Feature" (UrbanOnto ontology, with definition). But the "market square," as a subtype of the "square" from UrbanOnto, is a subclass under "square" from the BDOT classification. During the harmonisation, the object type from UrbanOnto was treated as subordinate to the class and categories with BDOT – as in the other cases, when the categories and classes of separate twin types matched.

P.4. During harmonisation there were four cases where giving two different labels to the same object type resulted in duplication without including "equivalent to" relation. In each of the aforementioned pairs, the first name is incorrect, and the second is the name appropriate for the type of object: "palace structure" (Polish: "założenie pałacowe," is an expression including both an architectural project and its implementation) and "palace complex" ("zespół pałacowy"), "higher education facility complex" ("szkoła wyższa kompleks") and "higher education facility" ("szkoła wyższa"), "barracks buildings" ("zabudowania koszarowe"), and "barracks" ("koszary"). It needs to be highlighted here that the OntoHGIS ontology also includes "barracks" as a subclass of both classes: "special dwelling" and "proper dwelling." We decided not to equate these two classes of "barracks" due to insufficient explanation of the definition in the OntoHGIS. The fourth problem in this category are synonyms of the type "urban plot," "plot," and "parcel."[30] The "parcel" object type appeared in the first version of the UrbanOnto ontology as part of the object "chartered town masterplan." Therefore, the type of object "parcel" was changed to "plot" and the relation to the type of "chartered town masterplan" is now related to it.

P.5. Another type of error is classifying related objects into other categories, i.e. an object higher in the hierarchy contains the meaning of a lower-order object (e.g. "office buildings" will be superior to "bank"). The class "jetty or pier" was assigned to the category "landmark" in the "objects" class, and the "pier" object type to the "other technical equipment" subclass in the "buildings, structures and machinery" class. The result of this error brought about one more consequence: two different classes of "pier" are being introduced in UrbanOnto ontology and both of them were used in relation to other and various classes. To retain the structure of the ontology in this case, during the harmonisation, the pier was subordinated both to classes "landmark" and "other technical equipment." Both "pier" classes (IRIs: 1. https://purl.org/urbanonto/object_type_b1c02f41-b3f1-40e9-9793-c730b56cf7f3; 2. https://purl.org/urbanonto/object_type_df3e96d3-6c4d-49f8-8e04-67dcbf9c9b34) were also equated to each other. This solution, however, is not elegant and further improvements are recommended here.

P.6. Working on the harmonisation and verification of ontologies allowed us to detect errors in the classification of objects, i.e. object classification inconsistent with type. One example is the incorrect classification of types of objects such as "municipal waste landfill" and "industrial waste landfill." The ontology definitions were incorrectly assigned to the "land use" class. Harmonisation made it possible to correct the notation. According to the BDOT ontology, these are types in the "land cover" class and in the "landfill" category. A more glaring example is the type of object "livestock building," which was misclassified as a complex ("industrial and economic complex"). The correct overarching category for this type of building should be the category of "buildings, structures and equipment" and "building" class, type: "farm buildings." The same error occurred with the property type "hotel." It was originally classified under the category of complexes "hotel service complex," subcategory "hotel or motel," although it was defined as a building ("a building that provides temporary paid accommodation"[31]). In the process of harmonisation, it was included as a kind of object type "hotel buildings."

P.7. Another example of a classification error is incorrect hierarchy. For example, the "sacral or monastic complex" object type from the UrbanOnto ontology was subordinated to the BDOT object type with the same name. These objects should have relation "owl: equivalentClass <IRI>." On the other hand, the type of facility "hospital complex" was originally classified as parallel to the type of facility "hospital or sanatorium complex," although it should be its subclass.

P.8. It also occurred that in the original version of the ontology, objects were classified at the wrong level of the hierarchy. The "railway station" object type turned out to be a type of "buildings, structures and machinery" object type. It should be correctly classified as in the BDOT model as a type of building in the category of "communication buildings, stations and terminals." An interesting example of an object type assigned to an overly general parent category is "milestone." This object type was originally added to the ontology as subclass "E18 Physical Thing" (directly to the types from the CIDOC CRM ontology, omitting the BDOT hierarchy). Thanks to harmonisation efforts, it has been assigned to a more precise class ("landmark") and category ("objects").

P.9. One of the assumptions of the UrbanOnto ontology was the lack of a one-to-many relationship between objects. During harmonisation, we came across two objects with this type of relationship, each with two subclasses. The "(pre-trial) detention centre" type of object was associated with both the type "building" (BDOT, category "buildings, structures and machinery") and the "other non-residential buildings not mentioned elsewhere" category, which itself is a subclass of the mentioned class, i.e. "building." Thanks to the harmonisation, "(pre-trial) detention centre" was correctly classified as a subtype of "other non-residential buildings not mentioned elsewhere." A similar situation took place in the case of the "gazebo" type of object. It was classified both as a subclass of the "landmark" and of the "shelter roofing or gazebo" type (being a subclass of the former type). Harmonisation allowed for the correct classification of the "gazebo" type as a subtype of "shelter roofing or gazebo."

P.10. In the first version of the UrbanOnto ontology, one could find types of objects without a full definition (e.g. "swimming pool," "pitch," "built-up area," "metro line," or "railway network"). It results from two assumptions of the implemented project. First, the UrbanOnto ontology is an open product that can be developed by publishing its subsequent versions. Secondly, the definitions used in the construction of the ontology are built not only from the classical definition, expressed in natural language, but – most of all – through the system of relations and connections between the types included in the ontology. It can therefore be assumed that the definition – for example of "park" – is not so much its short description, but the connection of the park with the "palace complex" and consequently, with other types of ontologies used by UrbanOnto. An example of such objects found within the framework of harmonisation may be "underground line" from the "transport network" category. This class does not have its own UrbanOnto definition, but appears in the definitions of other classes. In the properties of the "metro station" we could find information that it is part of the "underground line." The "built-up area" type of objects appeared in ontology only because one

of the authors wrote that the "school" and the "school complex" are part of the "built-up area," and the "buffer green area around town" only because one of the authors stated that the "park" object type could be a part of it. As one of the assumptions of the ontology was that in the relations ("is composed of," "forms part of") between the types of objects only types with full definitions are taken into account. Therefore, in the harmonisation process it was proposed to enrich definitions of "underground line," "buffer green area around town," and "built-up area."

In summary, the problems identified in the verification process concerned:

P.1 no "owl: equivalentClass <IRI>" relation for twin types from BDOT and UrbanOnto ontologies;
P.2 object types with the same label but different character;
P.3 same type of object (character and label) in different categories;
P.4 two types of objects of the same character, but different label;
P.5 related types of objects in different categories;
P.6 inconsistency between the type of the object and category;
P.7 subordination of twin objects types/the objects that should be subordinated are on the same level of hierarchy;
P.8 assigning an object type to a category that is too general;
P.9 double subclass (one-to-many relationship);
P.10 object types without a full definition.

Gomez-Perez[32] named following types of errors in relation to classes and instances: circularity errors, partition errors, semantic errors, incomplete concept classification error, omission of disjoint knowledge, redundancy errors, including grammatical errors and identical formal definition errors. Some of the problems identified in work with UrbanOnto ontology could be mapped to the errors named by Gomez-Perez.[33] "Subclass partition with common classes"[34] is in our case described in Section P.3. as the same type of object (character and label) in different categories. The example of two types of objects of the same character, but different labels (P.4.) is the type of redundancy error described as the "identical formal definition of some classes."[35] We have also diagnosed error of "redundancies of subclass-of relations (indirect repetition)"[36] in case described as P.9. double subclass (one-to-many relationship). An example of the "circularity error"[37] is the subordination of twin objects types (P.7.) and the inconsistency between the type of the object and category (P.6.) represents the "semantic inconsistency error."[38] The other five types of problems we encountered could not be mapped to the types of errors proposed by Gomez-Perez.[39] This is due to, *inter alia*, the assumptions of the UrbanOnto ontology (e.g., P.1. functioning of the twin types, P.10. object types without a full definition).

Validation – BDOT and UrbanOnto ontologies versus old city maps

In our case, validation to determine the compliance of an ontology with reality is sensitive/precarious, because it must refer to historical sources and not to a specific

modelled physical world. First, one must take into account ontologies used in the process of UrbanOnto construction: BDOT ontology models the world in order to standardise topographic maps, and OntoHGIS ontology models both administrative units and settlement types. UrbanOnto is an ontology that models the world (historical town space), taking into account its potential changes in time.

Thus, validation does not concern the model and world (1:1 relation), but the model and a representation of the world in the source. Hence, using the whole model made of three ontologies requires interpretation by a domain expert. Experiences in ontological approach as modelling technique of old maps were discussed *inter alia* by Svedjemo.[40]

In the validation part, we decided to focus on the maps of Warsaw – the city that was the subject of our case study in the HOUSe project. We took into account the maps issued before 1939 (as this date outlined the time frame for design work) and described in the series "Plans of Warsaw" ("Plany Warszawy") published by the Museum of Warsaw (Muzeum Warszawy).

Old maps of Warsaw selected for analysis (year, author, title, scale):

1 1655, Erik Jönsson Dahlbergh, "Urbs Warsovia…," approx. 1:4,000;[41]
2 1768, Georges Louis Le Rouge, "Plan de Varsovie…," approx. 1:6,900;[42]
3 1825, Korpus Inżynierów Wojskowych, "Plan Miasta Stołecznego Warszawy…," 1:4,800.[43]

We decided not to analyse the maps from the twentieth century. The cartographic source from 1912 discussed in series is a levelling map[44] ("Plan niwelacyjny miasta Warszawy…" made under the direction of William Heerlein Lindley). Therefore, the main aim of the authors was to present a lay of the land, not an urban fabric. In turn, the map published by Książnica Atlas in 1939[45] was made at a completely different scale than the maps of the previous centuries (1:25,000), and therefore it would be difficult to compare with older materials.

We analysed the text of the subsections in which Paweł E. Weszpiński described the content of the maps, as well as the objects marked on the editions of the maps that are part of the publication. For the purposes of comparing the types of objects presented in the old maps of Warsaw, we took into account all the sites identified by P. E. Weszpiński on the maps. This strategy resulted from 1) the structure of the publication containing editions of Warsaw's maps, and 2) the above-mentioned specificity of modelling the world in UrbanOnto. The objects presented on the analysed maps belonged to the world represented by the maps of Warsaw made available as a result of their edition. This dualistic approach results from the current state of work on the UrbanOnto domain ontology and shows the specificity of working with editions of cartographic sources.[46] It is also worth emphasizing that the correlation between cartographic representation and historical commentary has already been noticed by the editors of the Irish HTA series. The IHTA indicates that both the text and the cartographic material should have common concepts; whatever is on the map should be reflected in the comment.[47]

Summing up, this part of the chapter is devoted to analysing the content of three Warsaw maps in relation to the object types from the BDOT, OntoHGIS, and UrbanOnto ontologies, in order to validate how the developed data model could be mapped to the historical data. The content of books was coded independently by two persons. Next, types of objects from each book were sorted alphabetically and juxtaposed in a spreadsheet. In case of discrepancies, we referred to the content of the book again. Semantically equivalent terms were merged. The lists of object types from three maps were combined into one table with a total of 253 different types of objects. The following number of object types was identified for each of the maps: 1655 – 82; 1768 – 71; 1825 – 186. Subsequently, we mapped the resulting list of object types to the types from the ontologies (BDOT, OntoHGIS, UrbanOnto). In this process, we took into account whether the object comes directly from the BDOT or OntoHGIS ontologies or was added at the stage of developing the UrbanOnto ontology.

We took under consideration only these labels, which were included in ontologies as rdfs:Label. These were decided by domain experts to be distinctive, therefore the most important from semantic point of view: observed in historical sources, used in official names, etc. We did not include synonyms or alternative labels (skos:hiddenLabel; skos:atlLabel) in the analysis, however, for anyone working with domain ontologies these synonyms and alternative labels are easily accessible, i.e. by simple search in ontology classes in Protege or any ontology viewer. Please note also that reading ontology by rdfs:Labels is the most accessible to humans as it is written in natural language and this is the reason we have chosen it for the validation process explained here.

We counted how many objects from each map could be assigned to any of the ontologies taken into account (Table 7.1). For 82 objects from the map from 1655, 41 were mapped to at least one type from the ontologies. For 71 objects appearing on map from 1768, we mapped 50 of them to at least one type from the ontologies. And in case of the map from 1825, 94 from among 185 object types were mapped to at least one type from the ontologies. Nine types of objects from maps (e.g. “school,” “building,” “hotel”) were mapped to more than one type from the ontologies.

Table 7.1 Number of objects from cartographic sources mapped to at least one type of objects from analysed ontologies.

MAP	*No. of types of objects from the source*	*No. of types of objects from the source mapped to types from ontologies*
1655	82	41 (50%)
1768	71	50 (71%)
1825	185	94 (51%)

Table 7.2 Number of types from ontologies used in mapping.

Ontology	*No. of all occurrences of object types used in the mapping*	*No. of individual instances of the feature types used in the mapping*
BDOT	82	64
OntoHGIS	18	15
UrbanOnto	75	68

We also counted the number of types of objects from ontology used for mapping, as well as individual occurrences of ontology types in the mapping (Table 7.2). For the BDOT ontology these were 82 objects (including 64 individual objects), for OntoHGIS 18 (15 individual), and for UrbanOnto 75 (68 individual).

In Table 7.3, we presented the types of objects that occurred on all three maps. Four ("palace," "market square," "river," "street") of the 21 terms repeated in all

Table 7.3 The content of the old maps of Warsaw in relation to the types of objects from the BDOT, OntoHGIS, and UrbanOnto ontologies.

Map			*Ontology*		
1655	*1768*	*1825*	*BDOT*	*OntoHGIS*	*UrbanOnto*
Gate ("brama," 1655 "porta")			-	-	Gate[a]
Building ("budynek," 1825 "budowla")			Building	Construction,[a] building	-
Watercourse ("ciek")			Flowing waters	-	Flowing surface waters
Valley ("dolina")			-	-	-
Monastery ("klasztor")			-	Monastery	Monastery
Church ("kościół")			-	Church	-
Eyot (1655 "kępa," 1768 "wyspa," 1825 "łacha")			-	-	-
Town ("miasto")			Town	City/town	-
Wasteland ("nieużytek")			Unused land	-	-
Garden ("ogród")			-	-	Garden[a]
Palace ("pałac," 1655 "palatium")			-	-	Palace
Property ("posesja")			Property	-	Estate[a]
Town hall ("ratusz," 1655 "curia")			-	-	-
Market square ("rynek," 1655 "forum")			-	-	Market square
River ("rzeka")			River	-	River
Escarp ("skarpa")			-	-	-
Hospital ("szpital")			-	-	Pre-modern hospital
Green area ("teren zielony")			-	-	-
Street ("ulica")			-	-	Street
Buildings ("zabudowa")			Development	-	-
Castle ("zamek," 1655 "arx")			-	castle	-

Sources: Bartoszewicz, Weszpiński (2017); Bartoszewicz, Weszpiński (2021); Wagner, Weszpiński (2017); *UrbanOnto* (2020).

[a] Lack of full definition in UrbanOnto or OntoHGIS.

three analysed publications were mapped to their exact counterparts in the UrbanOnto ontology. The term "hospital" was mapped to the "pre-modern hospital" (UrbanOnto) due to the nature of the facilities presented in the analysed maps.

During the analyses, our attention was drawn to the fact that in the first version of the ontology the type "gate" did not have a complete definition, but was defined as part of (property "is composed of") the type "town walls." On the other hand, a subtype of "gate," i.e. "town gate," had a full definition. Similarly, the "garden" object type did not have a complete definition, and was defined as a part (property "is composed of") of the type "educational complex." A similar problem has arisen with the "property" object type, which occurs in both the BDOT ontology and the UrbanOnto ontology. Unfortunately, the second ontology lacks a complete definition, and the type is defined by being part of the "frontage" and "urban block" types (property "is composed of"). In Table 7.3, UrbanOnto types which do not have full definitions are marked with a letter "a". The term "watercourse" (in Polish "ciek"), used in the analysed editions, was the closest in meaning to the type of "land cover," i.e. "flowing surface waters", which was defined both in BDOT and UrbanOnto ontologies.

The term "wasteland" (in Polish "nieużytek"), which was used repeatedly in all the publications analysed, was semantically closest to the type from the BDOT ontology, i.e. "unused land." The meaning of the term "development" corresponded exactly to BDOT type "development" (subtype "land cover").

It has proven useful to use the OntoHGIS ontology as the basis for the UrbanOnto ontology. We have mapped the terms "church" and "castle" directly to the types in this ontology. On the other hand, the "town" and "building" types correspond to both the types from the OntoHGIS and BDOT ontology, and the "monastery" type to the objects defined in OntoHGIS and UrbanOnto.

The terms "valley" and "escarpment" do not appear in either the BDOT ontology or the UrbanOnto ontology. As a rule, in the BDOT system, terrain relief is presented with contour lines and elevation points, so individual types of relief are not described in the model.[48] Also, the term "green area" was not present in any of the ontologies due to the adopted BDOT model. In the BDOT model, "land cover" is the superior category for this type of objects, and its subtypes corresponding to vegetation are: "grasses and crops," "shrub," and "forest and wooded area." There was also no type in the ontology that directly corresponded to the term "townhall." In terms of meaning, the object type "office buildings" from the BDOT ontology was the closest, but certainly in future works the "townhall" object type should be defined as its subtype. The term we also failed to map to any ontology type was "eyot" (in Polish "kępa," "łacha"). The presence of this concept in each of the three studies on the old maps of Warsaw results from the city's location on the Vistula, which is the largest river in Poland.

Three types: "brickyard," "castle," and "factory" are interesting examples of a waterfall validation among ontologies. These three types are modelled in OntoHGIS ontology. "Brickyard" and "castle" are included twice as subclasses of class "building" and as subclasses of class "production dwelling," among "improper dwellings" (brickyard) and "proper dwelling" (castle). Objects

observed in our mapping (objects from old maps of Warsaw) are mapped to subclasses of "building." During the mapping process, we could observe that this mapping is impossible for "factory" identified in a plan from 1825, as we detected different classification in OntoHGIS. Despite modelling it twice also, we do not find a factory there as an "object" (building or complex of buildings or constructions). Factory was modelled as 1) subclass of "production dwelling" (as brickyard mentioned above) and as 2) subclass of "settlement," where it is labelled as "industrial settlement." In this class we can find "inn" or "sugar factory" or "urban settlement." Therefore, we could not connect "factory" from UrbanOnto with any class from OntoHGIS ontology and as a result, we could map the object from the 1825 map only to a class from UrbanOnto. The second result here was to note possible inconsistency in a domain ontology OntoHGIS, which was not detected before without validation by mapping to historical sources.

Conclusions

Due to the assumptions of the HOUSe system (for example, equivalent types of objects), in the first version of the UrbanOnto ontology we found errors that had not been mentioned so far in the literature as typical errors in the development of the ontology.[49] The verification made it possible to provide potential users with the second, improved version of the UrbanOnto ontology. This chapter may be of use to future teams who decide to implement and develop an UrbanOnto ontology in their projects. We hope that a detailed description of the errors that appeared during our work will help to avoid them in the future.

The basic conclusion from the analyses presented in this chapter is that the ontology needs to be expanded with basic terms such as "gate," "town hall," or "garden." When defining the latter object type, one should take into account the dualism of the concept. The garden currently present in ontology is understood as part of the school area, yet it can be understood as a recreational area. In future work on the ontology, gardens located at the back of urban plots, i.e. areas that constitute a type of cultivation, should also be taken into account.

On the other hand, it turned out to be valuable to include object types in relation to the epoch in the UrbanOnto ontology, e.g. in the case of a "pre-modern hospital." In editions of the maps, facilities of this type were simply described as a "hospital." However, being aware of the reality of the era presented by the map, it can be mapped to the type of "pre-modern hospital" from ontology.

The model developed as part of the HOUSe project does not include vernacular language, e.g. "green areas." Such "general" concepts cannot be mapped to the model and thus they are lost in the process of source interpretation with the help of an ontology.

Overall, taking into consideration all the above-presented number of ontology object types, we cannot unequivocally state which of the ontologies – BDOT or UrbanOnto – is better suited to work with cartographic sources. The analysis proved that the OntoHGIS ontology constitutes a valuable complement to the ontologies dedicated to urban space (BDOT and UrbanOnto).

The analysis of the content of maps made in different ages in relation to ontology helps follow both the development of the urban organism and the perception of the city by those responsible for map-drawing. The ontology provides and serves as a consistent point of reference in the interpretation of the source. The UrbanOnto ontology is one of the first steps in developing tools for the comparative history of towns. We hope that our work will *open the door* to further work on the standardisation of studies on historical urban spaces.

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8 Cartography and the city

Exploring urban ontologies through historic town-maps

Katarzyna Słomska-Przech and Keith D. Lilley

Introduction

"How many maps, in the descriptive or geographical sense, might be needed to deal exhaustively with a given space, to code and decode all its meanings and contents?" This is a question posed by Henri Lefebvre in his spatial theories explored in *The Production of Space*.[1] It is a question that has relevance in any explorations of mapping urban spaces, and in particular in "opening-up the map" and thinking about historic town-maps and their uses in urban histories and urban morphologies.[2] Here, a systematic analysis of their cartographic content offers an interesting and useful exercise in identifying urban features as "types." The cartographic conventions to be found on historic maps of towns and cities are particularly important for classifying the elements that make up urban spaces. The aim in this paper is to explore the urban types defined in the HOUSe project ontology ("UrbanOnto") through large-scale historic maps of 1:2,500 scale that show in detail a range of urban features. The UrbanOnto ontology models definitions of terms related to historical urban space, responding to the needs of the research community for uniform terminology, which is crucial for comparative urban studies as it is prerequisite of mutual understanding of researchers.[3] In urban morphology, large-scale maps or plans of towns and cities are key sources for analysis, since at this scale the topographical details of individual buildings and plots are shown, including boundaries between properties and street-furnishings.[4] There is a very important divide between those large-scale topographical maps that show plot-boundaries ("lot" boundaries in American English), usually 1:5,000 and greater, and those smaller-scale maps (usually 1:10,000 and less) that do not. Here "map" is used to cover cartographic representations in these larger scales, recognising that the term "plan" is typically used more to refer to the largest-scale mapping, of say 1:500 and 1:1,000 most commonly, as in urban planning, architectural site-plans, and property conveyancing, for example.[5] In Polish cartography, the word "plan" is associated with town plans.[6] As the Polish cartographic milieu has always been closely related with German and Russian cartographic communities, the projection is commonly mentioned in the literature as a prerequisite for maps.[7]

Cartographic sources, along with written sources and expert knowledge of the participants of the HOUSe project, are one of the foundations for building the

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UrbanOnto ontology. In this chapter, our goal is to validate the model presented by the ontology with the models from two different cartographic sources.[8] In the validation process we take into account two types of cartographic materials. First is a Polish town-map prepared under supervision of William Heerlein Lindley[9] that is without a map legend, therefore a source without explicit thematic frame and a key to read the model. The second study material is a map-sheet from a highly standardised map series – the Ordnance Survey (OS) of Great Britain. The legend to OS maps is widely described both in the official documentation and in the literature on the OS map series.[10] Importantly, both selected cartographic sources share the same scale of 1:2,500 and were developed in a similar period (at the turn of the 19th and 20th centuries). The two late-19th century maps considered here as case studies also relate to similarly industrialised urban centres of the mid- to late 19th century, Coventry and Warsaw. Moreover, both places share similar characteristics, being located inland and with urban landscapes that capture the impact of industrialisation at the time Lindleys' map and the OS 1:2500-scale map were produced. While Warsaw's population in 1897 at 601,408[11] (in 1897) was larger than Coventry's (118,004 in 1911),[12] both were expanding through in-migration. Warsaw and Coventry were regionally important at this time, with centralised administrative functions. Critically, Warsaw was also the main case study used within the HOUSe project, and so offers a useful basis for comparison with Coventry, using their large-scale town-maps, by Lindleys and the OS respectively.

Procedure

Methodologically, here we compare the types of objects on two maps to one common list of objects from the UrbanOnto ontology (including OntoHGIS and BDOT).[13] This process is summarised by Figure 8.1. It is modelled on the approach taken in this study of Coventry and Warsaw but has wider application for cases where there are maps without legends but have a standardised symbology for mapped urban features.

In the case of *maps without a legend*, in the first step we benefit from drawing on the data on objects for the area of Warsaw created by the database developed in the HOUSe project. Here, data are identified using Lindleys' map, then this information is used for initial reconstruction of the legend (Figure 8.1, 1a). Next, we can analyse additional cartographic materials from the same series of publications (Figure 8.1, 2a). In this second step, symbols are compared using those from map sheets in other scales and Lindleys' map, and then matched with the ontology object types. If there are no cartographic materials from the same publishing series, other maps developed in a similar period can be used for comparative purposes. In the last step (Figure 8.1, 3a), we analyse the content of the map sheets in order to complete the list of object types obtained in the previous two steps.

When working with *maps with a legend*, in the first step we mapped object types listed in the legend to the types of objects from the UrbanOnto ontology

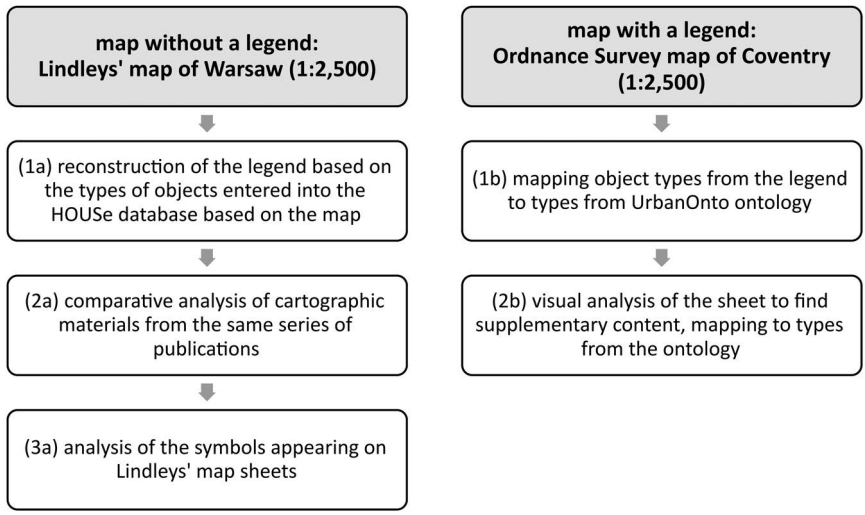


Figure 8.1 Stages of mapping the types of objects occurring in old maps to the types of objects from the UrbanOnto ontology.

(Figure 8.1, 1b). In the second step (Figure 8.1, 2b), we performed a visual analysis of the map-sheet to find any additional contents and map these supplementary object types to types from the ontology.

Case studies – Old town-maps

Map without a legend – Lindleys' map of Warsaw (1:2,500)

When choosing a map for a case study, we follow two criteria. Firstly, the main case study in the HOUSe project is the city of Warsaw. Secondly, the project refers to the Historic Towns Atlas series.[14] Therefore, as the main base map for the project needs we choose the same map, which is planned to be used as the main map of the HTA volume devoted to Warsaw,[15] i.e. a 1:2,500 scale map made in the years 1897–1901. The map was developed as part of the work on the city's water supply and sewage systems.[16] At that time, a whole series of maps were made in scales from 1:200 to 1:25,000.[17] These were the first such precise maps of Warsaw based entirely on mathematical calculations and geodetic control network points. The map at the scale of 1:2,500 presents plot boundaries and plot numbers. The main language of the map is Russian, as Warsaw was under Russian partition in the 19th century. Maps from the discussed series are commonly referred to as "Lindleys' maps," after the chief engineer overseeing the work – William Heerlein Lindley.[18] At the age of 17, William H. Lindley started working with his father, William Lindley, who was an engineer known all over Europe.[19] During his career, he participated in engineering works, *inter alia*, in Frankfurt am Main, Saint Petersburg, Łódź, Baku.

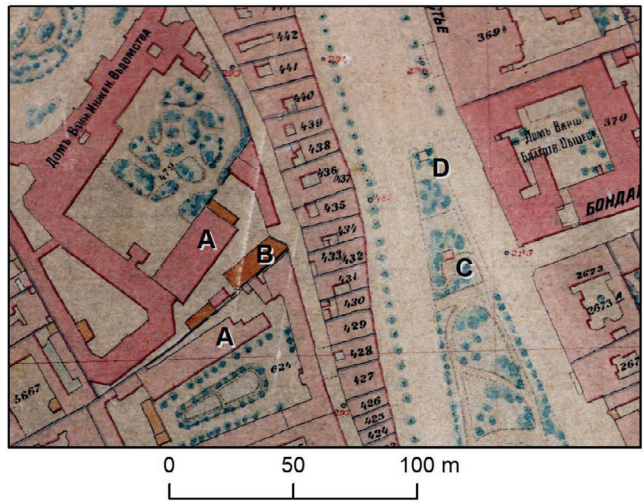


Figure 8.2 Fragment of Lindleys' map at a scale of 1:2,500: A) brick building, B) wooden building, C) public toilet, D) monument.

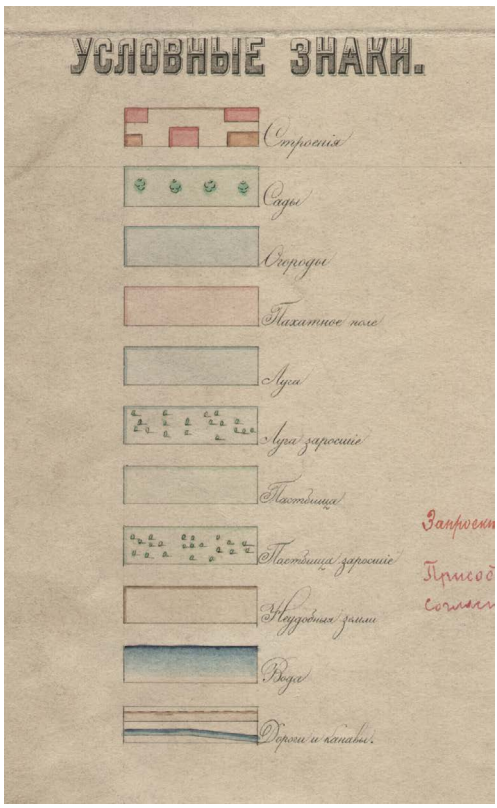
Source: State Archive in Warsaw, 72/1001 sig. 785, sheet no. 12.

The special purpose of the map, which was to assist with engineering and construction work, influenced the symbolization used. The main distinction between buildings is based on the construction material. The orange colour presents wooden buildings, and red – brick buildings (Figure 8.2). Interestingly, the same symbol as for the buildings is used to mark crosses, chapels, or monuments. The building symbols might indicate that for the people who prepared and used the map, the aspect of stability of terrain obstacles was more important than the possibility of orientation in the field with the help of this map. Interestingly, some monuments that existed at that time, such as figures of saints, or a stone with a commemorative plaque, are not included on the map at such an exact scale.

The disadvantage of the 1:2,500 scale maps is the lack of a legend. A small number of examples of symbols (named as "conventional signs") used on the maps appear only on two different sheets at the scale of 1:1,000 from 1906 (Figure 8.3, left) and 1895–1896 (Figure 8.3, right). Legends to maps in lower scales (1:10,000, 1:16,800, and 1:25,000) cannot be applied as due to the level of detail the symbolisation is entirely different.

Reconstruction of map legend based on entries to HOUSe Warsaw's database

During the HOUSe project, the historians enter various objects established and existing in various time slots, between late Middle Ages and the very beginning of WWII, into the spatial database. In the assumption, the database is not supposed to be a finished and closed product, but it should be open for future developments. Therefore, it does not exhaust the list of UrbanOnto objects types. During the work on this chapter



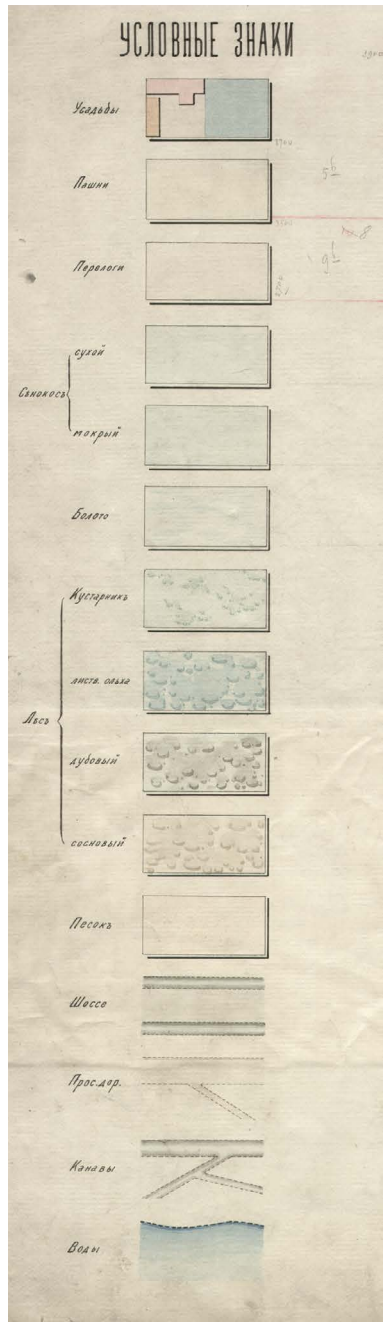


Figure 8.3 Two sets of conventional signs from the map sheets at the scale of 1:1,000.
Source: State Archive in Warsaw, 72/1001 A old sig. L 712; B old sig. L 713A, reduction.

in May 2022, there were 1,142 objects in the database. For 575 objects, Lindleys' map at the scale of 1:2,500 is named as the cartographic source. In the analysis, we exclude objects whose lifetime (*date_range*) does not coincide with the state presented on the Lindleys' map. If several objects that meet the above criteria are found in the database, the first occurrence in the database is used to define the symbol.

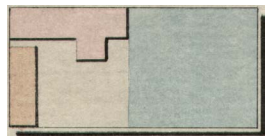
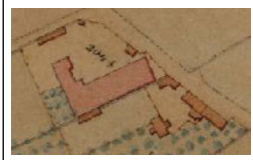
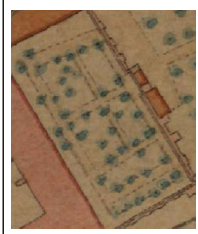
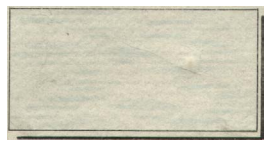
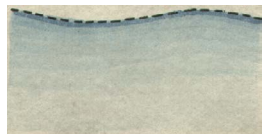
The list compiled on this basis includes 55 types of objects. For ten of them, which are mainly a subtype of the land-use complex, as well as the land cover type, we do not find any distinctive symbols (*inter alia* waterworks, palace complex, market or bazaar, kindergarten). The two markets shown on Lindleys' map are labelled with names of districts, but are not described as a market square. The list of object types entered into the HOUSe database based on Lindleys' map make it possible to recognize symbols for 45 objects. As many as 37 of them are buildings in terms of the categories from ontology and are also marked on the map with the building symbol (Figure 8.2). Less than half of them (14), are additionally labelled (e.g. railway station, market hall, barracks, church, fire station, synagogue, hospital). The existence of a unique symbol is found for objects such as a cemetery, street, water intake, and freestanding fountain. On the map, wooded and shrubbery areas – i.e. parks and gardens – are presented similarly. For the fort and the square, only labels are used.

Comparative analysis of cartographic materials

The above-mentioned two sets of symbols from Lindleys' maps at the scale of 1:1,000, which contain successively 11 and 15 symbols (Figure 8.3),[20] constitute the basis for the second stage of the reconstruction of the legend of the map at the scale of 1:2,500. Comparing the scope of the content of the map of interest (1:2,500) with the symbols from the same series sheets (1:1,000), only 9 out of 24 types of object from the maps at a larger scale can be found on a map with smaller scale, and consequently be assigned to types from the ontology (Table 8.1).

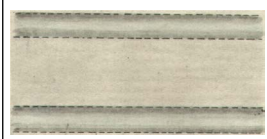
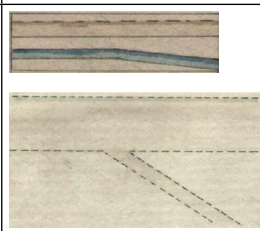
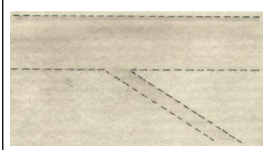
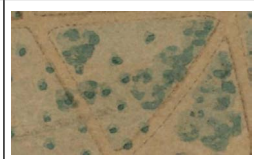
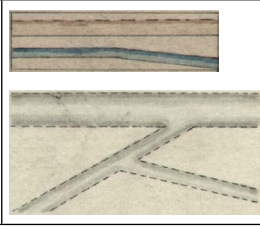
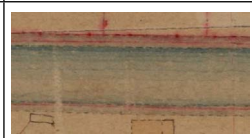
Three types of objects ("waters," "roads," "ditches&canals") appear in both legends (1:1,000) and in map at the scale of 1:2,500, but are symbolised differently. Symbolisation for the waters vary in terms of a shoreline – solid or dotted line – and both symbols are used on the map at the scale of 1:2,500. Roads and canals differ in colouration between the lines amid the 1:1,000 sets. In one set, ditches and canals are filled with blue, and in the other set – grey. Probably, it depends on whether they were filled with water. Examples of the use of both symbols can be found on the map at the scale of 1:2,500, i.a. in the vicinity of the Warsaw Citadel. When it comes to transport routes, at the 1:2,500 scale map, roads and chaussees have the same symbol, but they can be distinguished by labels. As there is no object type corresponding to chaussees in the UrbanOnto ontology, we classify them to the same type as "roads." Moreover, as in the work of T. Panecki,[21] all swamps and wetlands are classified as "wetlands" due to the lack of feature that distinguishes them. Another ambiguity arises in the case of gardens. In the legend to the 1:1,000 map, geometric, parallel rows of green dots symbolise gardens. In the HOUSe database, an area with irregularly placed trees or shrubs symbols (the same as can be found

Table 8.1 Attempt of mapping symbols from Lindleys' maps at the scale of 1:1,000 to symbols from map at the scale of 1:2,500 and types of object from the UrbanOnto ontology (own elaboration, based on Żelichowski and Weszpiński 2016, p. 176, source: State Archive in Warsaw, 72/1001, old sig. L 712; old sig. L 713A, sig. 785).

Symbol from Lindleys' maps at the scale of 1:1,000			
type of objects *English translation [Polish translation]*	*Symbol*	*Symbol from Lindleys' maps at the scale of 1:2,500*	*Object type from UrbanOnto*
Buildings [budynki]			Building
Estates [siedliska]			Property
Gardens [ogrody]			Garden
Swamps&wetlands [bagna, podmokłości]			Swamps
Waters [wody]	 		Surface water

(*Continued*)

Table 8.1 (Continued)

Symbol from Lindleys' maps at the scale of 1:1,000		*Symbol from Lindleys' maps at the scale of 1:2,500*	*Object type from UrbanOnto*
type of objects *English translation [Polish translation]*	*Symbol*		
Chaussee* [szosy]			Road
Roads [drogi]			
Alleys [aleje i drogi]			Alley
Ditches&canals [rowy, kanały]			Drainage ditch/ channel

* Chaussee is an old-fashioned term for highway or country road; "Chaussee," accessed 18 January 2023, https://dictionary.cambridge.org/dictionary/german-english/chaussee.

in parks) is entered into the database as a "garden." To the east of what is marked in the database, is an area with regular rows of green dots. Perhaps the localisation in the database is incorrect, or the garden is a common name for the whole area and therefore it is also chosen as an object type.

The types of land cover, such as meadows (wet and dry), pastures, and arable land, differ so little in shades that it is difficult to distinguish them in the legends to the map at the scale of 1:1,000. It is not possible to find these types of land cover on a map at scale of 1:2,500. Discoloration of the paper prevents the identification of colours. Additionally, there are differences in the colouring of areas between the sheets (Figure 8.4), possibly due to the fact that they were the result of the work of various teams, or the

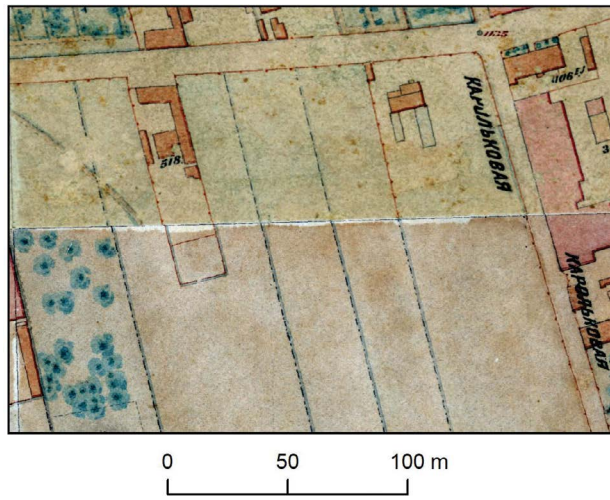


Figure 8.4 Differences in colours between sheets.

Source: State Archive in Warsaw, 72/1001 sig. 785, sheet no. 10 & 14.

use of a different dye. Therefore, it is difficult to determine whether the vast areas to the west of the city borders were covered with cultivated gardens, meadows, or pastures. On the 1:2,500 scale map, no symbols are identified for overgrown meadows and pastures, sands, or three types of forest (alder, oak, and pine forest).

Analysis of the symbols appearing on the map sheets at the scale of 1:2,500

Visual analysis of the content of the map sheets at the scale of 1:2,500 allows us to find additional symbols over and above those mentioned in two previous sections.

As part of the "surface water" class (category "land cover"), we compare a "lake" and a "pond," but we do not find any difference between the symbols. We also analyse types of objects within the water network category ("river" and "stream, torrent or creek"). We choose the Vistula River as an example of its kind. However, due to its size, it has a symbol similar to surface waters. We are also able to identify types of objects directly or indirectly related to hydrography, such as "flood gate," "groyne," "swamps," or "bridge."

Due to the uncertainties with regard to the symbolisation of meadows and farm lands, the green areas are jointly assigned to the class "grasses and crops" from the category "land cover." The shades of green on the map are more clearly visible on the copy from Warsaw's Map Services.[22] The same shade is used for woodless areas of parks and plots of land outside the built-up area of the city.

We also confirm that the same building symbol appeared for other identified types in this class, for example a "grain elevator" or "philharmonic hall." Buildings are the most extensively represented group of objects from the UrbanOnto ontology at Lindleys' map. Some of the more important buildings, for example "barracks," "churches," have an additional label.

Noteworthy is the marking of religious buildings on Lindleys' map, because only for these buildings an additional symbol is used (apart from colouring). For two types of "buildings intended for religious worship and religious activities" (Catholic and Orthodox churches) an additional symbol of the appropriate cross is used. On the other hand, synagogues or Protestant churches are marked only with the label. Unfortunately, the UrbanOnto ontology lacks the type of object which would match exactly Catholic or the Protestant church object types. Currently, they can be classified as "buildings intended for religious worship and religious activities" or as "church" (an object type derived from the OntoHGIS ontology). There is a need to choose – whether we want the church to be in the same class as other temples, or whether we want it to be classified as a church.

"Statues" and "gates" (types in the category "object") or "free-standing chapels" are also marked with the symbols for buildings discussed above (Figure 8.2). For this reason, it can be difficult to distinguish them from other small buildings. Probably it can be explained by the purpose of the map (construction of the water supply system). However, due to the lack of separate symbols, the map is less informative.

Mapping of the symbols used on Lindleys' map at the scale of 1:2,500 with the UrbanOnto ontology has scope to facilitate similar work with other maps. To explore this potential there are a wide range of 1:2,500 scale maps of towns and cities across Europe. These include "cadastral" mapping for a number of countries, of the early to mid-19th century, including France and Germany,[23] state surveys that map property for the purposes of registration and valuation in particular. This scale of map is especially valuable in researching urban landscapes as it provides a high level of topographical detail, including individual buildings and plot boundaries, as evident with Lindleys' map for Warsaw. It is also the case for the OS in Great Britain and in Ireland, where 1:2,500 scale mapping has a long history of use over the 19th and 20th centuries,[24] and here is used to offer a parallel case study to Lindleys' map examined so far, and so provide a basis for comparing the content of such maps between countries, and using this approach to reflect on the application and transferability of UrbanOnto ontology.

Map with a legend – The Ordnance Survey (OS) 1:2,500 map of Coventry

For the purpose of this comparative assessment of historic town-maps and the application of UrbanOnto, the focus here will be the OS 1:2,500 County Series of Great Britain.[25] These large-scale topographical maps have proved invaluable for morphological analysis of towns and cities in Britain, and because they also form the basis of the latest mapping of the British Historic Towns Atlas series.[26] The 1:2,500-scale County Series is also contemporary with Lindleys' map for Warsaw, so forms an appropriate comparison, not just in terms of their common scale but also their shared dates of production and comparable uses for historical urban mapping.[27] The 1:2,500 series is not ubiquitous in its geographical extent of Britain, however, as it excludes upland areas, which in Scotland included large tracts of the Highlands and Islands, as illustrated here (Figure 8.5), while in England and Wales more mountainous parts, notably in Northern England and Wales, were similarly

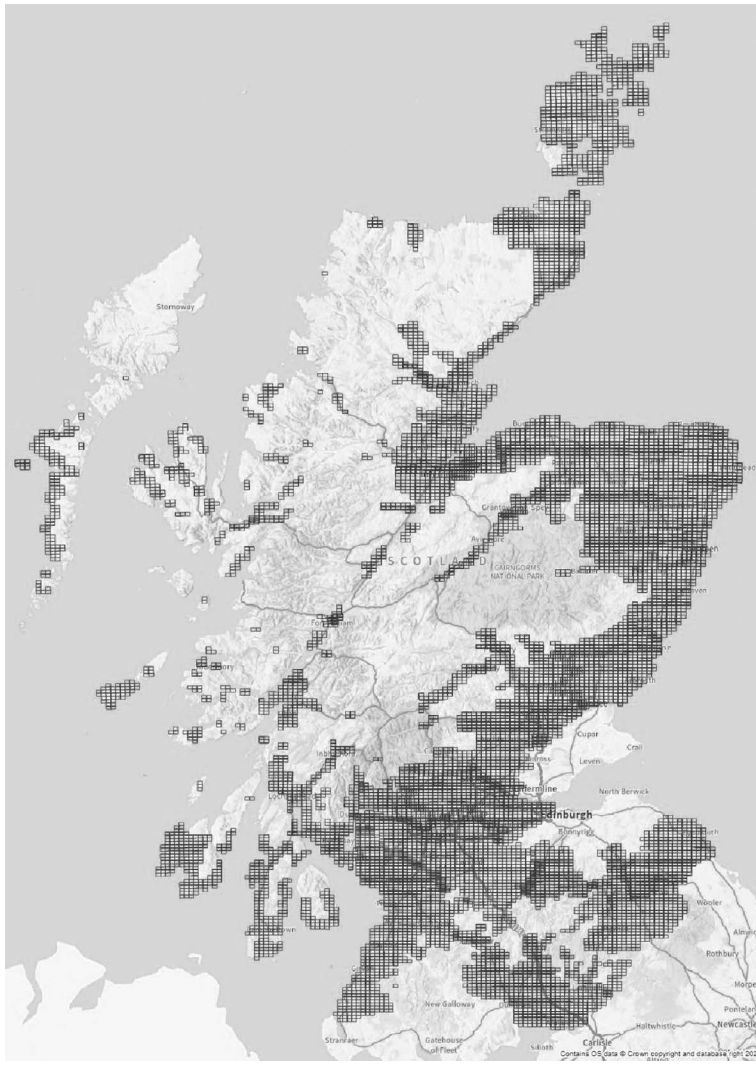


Figure 8.5 1:2,500-scale coverage in Scotland, County Series indicated in black, image derived courtesy of National Library of Scotland.

not covered at this scale. But cultivated rural areas and populated urban areas of the country were mapped at 1:2,500, and the County Series proved to be important at the time – for land management and valuation, architectural and civil engineering projects, administrative and governmental purposes, such as boundary changes – and also for transport and railway planning and construction, as well as urban sanitation, drainage, and sewerage schemes, both of these aspects of landscape and urban change being so much a feature of the late-1800s period. Indeed, it is on the latter use that the OS 1:2,500 scale maps share a common purpose with Lindleys' map

created for Warsaw, and other similar maps produced by the company for cities elsewhere in Europe, such as Hamburg.

More commonly known in the UK as the "twenty-five inch" scale (25" to 1 mile), the OS 1:2,500 series of maps first date from the 1870s following recommendations made by the Davidson Committee after the OS's "Battle of the Scales," which was settled in 1863.[28] The aim was to have Britain covered at this scale by 1890, completing the "County Series," though with the longer term aim of recasting the series on a national projection rather than individual county basis. The latter presents the user with a complex sheet numbering system, with each county having its own sheet numbers, based on the coverage diagrams of the OS's smaller-scale 6-inch to one mile maps (1:10,560). For each 6" sheet there were within it sixteen 25" sheets, and while the 6" numbering system used Roman numerals, the 25" used Arabic numerals, the 25" sheet sequence starting in the north-west corner and finishing in the south-east. For the historic core of Coventry, for example, the 25" sheet is Warwickshire XXI.12 (Figure 8.6). The County Series sheets covered an area of one mile by one and half miles, but no grid is shown on the map. Instead the map-sheet margins typically comprise revision and survey information, and included a limited number of standard conventions, the "characteristics and symbols" present on the 25" map. The 1:2,500 County Series was later replaced by the National Grid Series after the Second World War.[29]

One of the useful quirks of the 25" scale for its users was one square inch on the map equated with one acre on the ground.[30] The map sheets included areas for parcels of land, and the 1:2,500 series is unique for OS mapping in this regard, a reference number that clearly had value for property conveyancing and valuations.[31] There is some similarity in this sense with many continental European large-scale map series of this period, including cadastral plans, also often mapped at 1:2,500. The County Series 25" "conventional signs" were the same as those used at the 1:1,250 scale by the OS, and were extensive, no doubt the reason why the map sheets did not include the full range, they run to over four A4 pages in Harley's[32] volume. An accessible version of the conventional signs and abbreviations for the 25" sheets is available online thanks to the National Library of Scotland (NLS), though this is for later revised edition of the 1920s, rather than the earlier editions.[33] Of particular note, for this scale, the first edition sheets of the 25" scale often were coloured by hand. The Coventry sheet (Figure 8.6) is a good example of this, and a close-up sample appears in Figure 8.7. Harley[34] notes these sheets, published up to 1892, included a colour scheme for buildings, with red for brick and stone, black for iron and wood, and blue for glass-roofed structures. Water features were also tinted blue while streets and roads appear in a pale creamy yellow. No other colours were used however, and colouring was discontinued at this scale for later revisions and editions of the series. Indeed not every 25" sheet was in fact coloured, some of cities (including Coventry) clearly were a chosen few. The coloured editions present a particularly striking and attractive image.

The use of colour is just one common aspect connecting Lindleys' map of Warsaw and the OS map of Coventry, and some similarities can be observed, such as

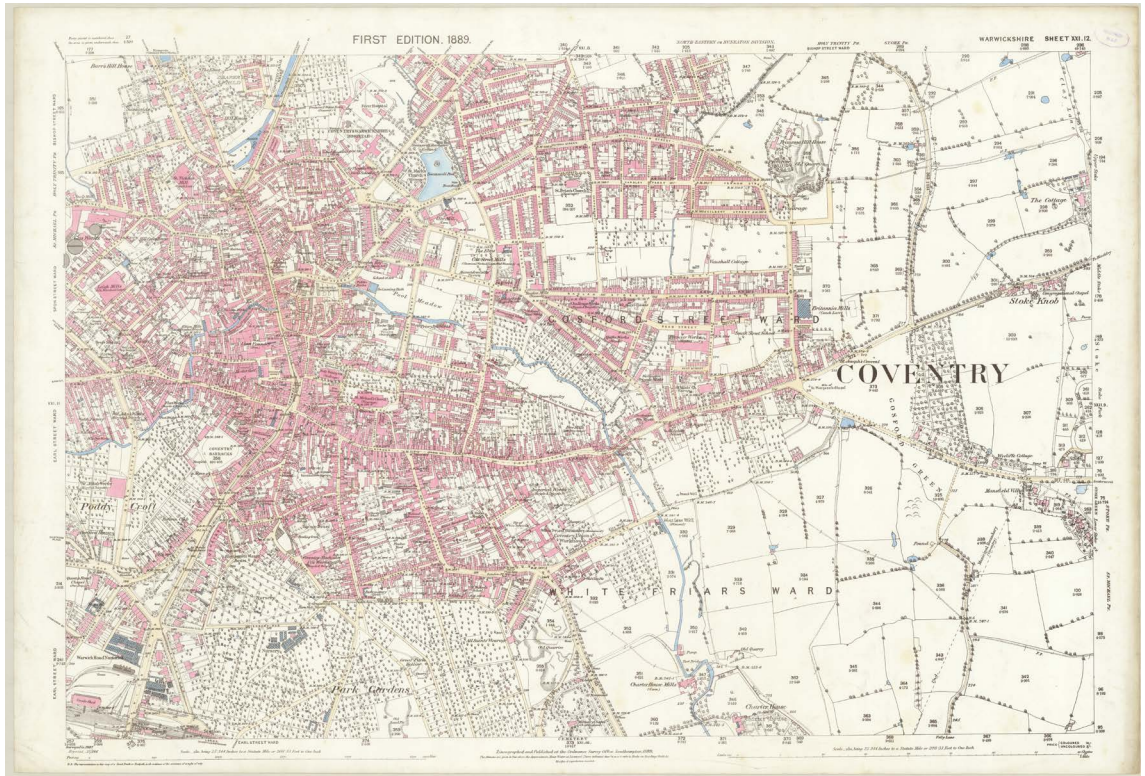


Figure 8.6 Coventry, OS 1:2,500 scale sheet. Warwickshire XXI.12. Surveyed: 1887, published: 1889. Size: Map 64.4 cm × 96.6 cm (25.344 × 38.016 inches), on sheet ca. 76 × 104 cm (ca. 30 × 41 inches).

Source: Courtesy of National Library of Scotland (https://maps.nls.uk/view/115634287).

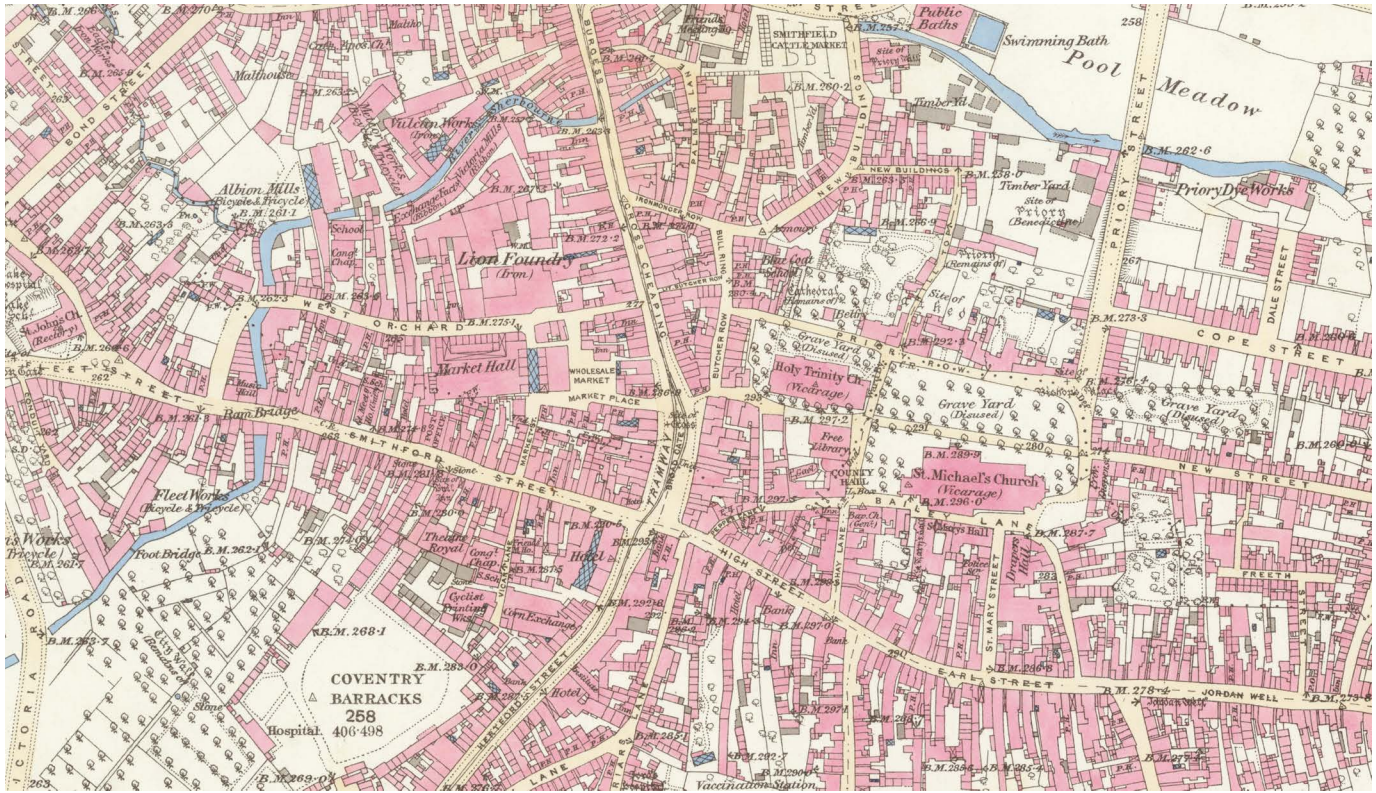


Figure 8.7 Extract, Coventry, OS 1:2,500 scale sheet. Warwickshire XXI.12. Surveyed: 1887, published: 1889.

Source: Courtesy of National Library of Scotland (https://maps.Nls.uk/view/115634287).

the use of pink for buildings. The OS 1:2,500 scale maps do have parcel numbers, as noted above, but offer limited representation of land-use. For example, the different uses of open and enclosed land on the edges of Coventry, for example towards the south, are not symbolised on the map. The presence of tree symbols being the main indication of vegetation, especially along field boundaries, and to indicate orchards. What was being cultivated in these fields is not revealed however. Similarly, buildings are almost uniformly washed in the same pink colour, not differentiating between what the buildings were being used for at the time, to get a sense of building use the map is full of labels. The map is characterised by numerous descriptions of urban features, including individual buildings, theatres, inns and pubs, institutions, factories and works, churches and religious buildings and so on. Of course, there are also toponyms including street-names. Recent digital transcription work, as part of a crowd-sourcing project on OS 1:2,500 scale maps led by the NLS, yielded over 30,000 transcribed names and words for "all of the text on the OS's 25-inch to the mile mapping for Edinburgh environs (1890s)."[35] These names on the 1:2,500 scale maps are in many ways more informative than the map's conventional signs, which are reasonably limited to a set of standardised topographical features, as well as administrative boundaries. Boundary information on the OS 1:2,500 maps is particularly characteristic and very detailed, ranging across civil and governmental types of boundaries which are not physically visible on the ground (unless specifically marked by a boundary post or stone). This aspect of the OS 1:2,500 map is quite different to Lindleys' works and has much to do with the maps' purposes and creators, the OS mapping being funded through the British state and the OS as a government mapping agency. However, while the OS 1:2,500 scale maps are "maps with legends," the lack of a *comprehensive* legend or symbology (that differentiates, say, between building use or land-use) makes this series of maps not so very different to Lindleys' map for Warsaw after all. Of course, unlike Lindleys' map for Warsaw, the OS 25" maps did change in appearance in subsequent revisions, and the series did have a set of cartographic conventions from the outset.

With their shared scale there is scope, then, for us to use Lindleys' map and OS 25-inch scale map to explore how HOUSe ontology (UrbanOnto) can be applied to a source-map – and historic town-map – of the same historical period. Using two different urban contexts and a map series with a standardised set of cartographic conventions and signs, the task is to take the Coventry 1:2,500-scale sheet of 1889 as a basis, and the object types identified above for Warsaw are examined, to draw out similarities as well as differences between their application. This offers an opportunity, too, to reflect further on the wider use of UrbanOnto for comparative research and analysis.

UrbanOnto comparisons through 1:2,500 scale mapping

Comparing Lindleys' map of Warsaw and the OS map for Coventry using the UrbanOnto types as a basis yields similarities and differences. These are worth reflecting on, one for what they reveal of standardisation in urban cartography's norms

and conventions, and mapping urban landscapes in industrialising Europe at the end of the 19th century, but also, secondly, for what emerges from the exercise to help reflect on the transferability of the UrbanOnto model to other spatial contexts beyond Poland. The UrbanOnto model comprises "categories" of urban feature at the top-level, and includes "buildings, structures and machinery," "land use," "objects", "land cover," "transport network," "water network," and "structures," all to be found on Lindleys' map for Warsaw. Ninety-five types of objects are present on Lindleys' map, however only 58 of these are marked with a unique symbol or label. Almost twice as few objects were identified on the OS 1:2,500 map for Coventry, 41 types of objects which have an individual symbol or are labelled. This preponderance of UrbanOnto types of object found on Lindleys' map relates of course to the use of this source in creating the HOUSe ontology, and the difference between Lindleys' map and OS map is highlighted. Notably too, Lindleys' map was a bespoke commission for Warsaw specifically, with an emphasis on water and sanitation provision in the city, whereas the OS 1:2,500 scale map for Coventry contains conventions necessary for a standardised mapping series at a national scale, created for and by a supranational state mapping agency. From Lindleys' map too, it is possible to identify more types of objects from the ontology among the buildings. These were buildings with no labels on the map, but identified by being entered into the HOUSe test database.

In comparing the cartographic conventions used on the Lindleys' map and the OS map, it is worth noting that some of these types of objects are specifically labelled on the OS map (e.g. factory, hotel, library, manufacture, school, gaol, and belfry). There is no particular symbol associated with these. From 107 types found on Lindleys' map and OS map, 30 are present on both maps (Table 8.2). More than half of these (16) are from the category related to buildings and constructions ("buildings, structures and machinery" from BDOT model or structure from OntoHGIS), of which 15 are building types (e.g. "bank," "almshouse," "theatre," and "church"), and one was the "civil engineering structure," i.e. "bridge." The second most numerous category is "land use" (seven types of objects: "market or bazaar," "property," "hospital or sanatorium complex," "higher education facility," "park," "garden," and "gasworks"). The three types from the "transport network" category that appear on both maps are: "road," "street," and "railway track." From the category "land cover," only the "pond" and the "market square" are repeated on both maps. From the "water network" – the one type identified on both maps is "stream, torrent or creek." Similarly, from the category "objects," there is only one symbol with similar meaning, i.e. the "tree or a group of trees."

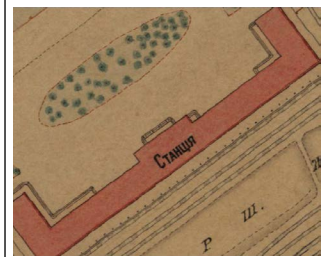
Lindleys' map includes a number of objects that do not appear on the OS map, particularly relating to water management, again a reflection of the purpose of Lindleys' map. For example, present in the UrbanOnto is a "water intake," "drainage ditch," "channel," and a "waterworks," all of which feature on Lindleys' map. None of these are present on OS 1:2,500 sheet XXI.12 for Coventry, partly they have a specificity based on the particular cartographic source used, but partly too because some of these objects just do not appear on this individual map-sheet for Coventry. The city's waterworks, for example, were situated just outside the sheet

Table 8.2 Examples of types of objects marked with a unique symbol or label and identified on Lindleys' map of Warsaw and OS map of Coventry (source of map extracts: State Archive in Warsaw, 72/1001 sig. 785; Courtesy of National Library of Scotland, https://maps.nls.uk/view/115634287).

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Buildings, structures and machinery	Civil engineering structure	Bridge			Bridge	
Buildings, structures and machinery	Building	Office buildings	Bank		Bank	
Buildings, structures and machinery	Building	Commercial and service buildings	Market hall		Market hall	

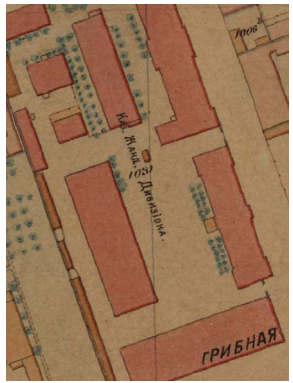
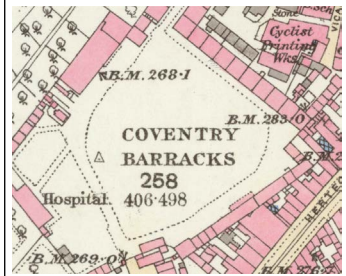
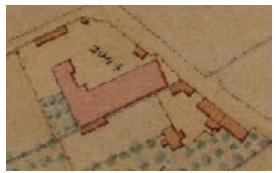
(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Buildings, structures and machinery	Building	Communication buildings, stations and terminals	Railway station		Railway station	
Buildings, structures and machinery	Building	Publicly accessible cultural facilities	Theater		Theatre	

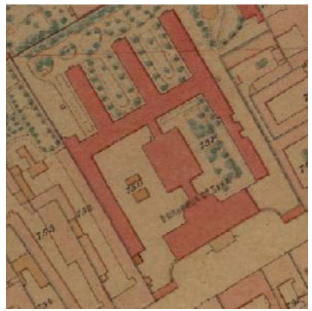
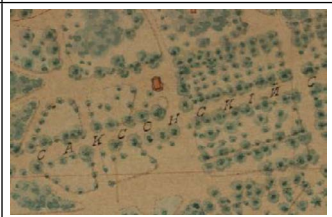
(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Buildings, structures and machinery	Building	Other non-residential buildings not mentioned elsewhere	Barracks		Barracks	
Land use	Residential complex	Property			Property (group)	

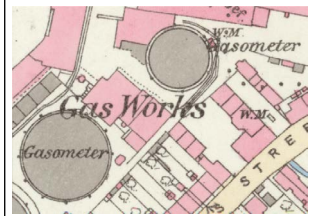
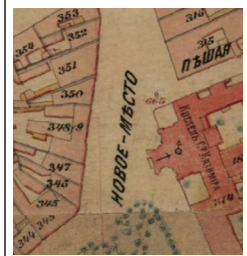
(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Land use	Health and social care complex	Hospital or sanatorium complex	Hospital complex		Hospital	
Land use	Sports and recreation complex	Park			Park (recreation ground)	

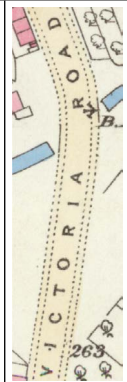
(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Land use	Industrial and economic complex	Gasworks			Gasometer (gas works)	
Land cover	Square	Square	Market square		Market place	

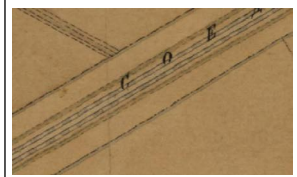
(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Land cover	Surface water	Stagnant water	Pond		Pond or pool	
Transport network	Road				Road	

(*Continued*)

Table 8.2 (Continued)

Category	*Class*	*Object type*	*Subtype*	*Symbol (Lindley)*	*OS type*	*Symbol (OS)*
Transport network	Road	Street			Street	
Transport network	Track or complex of tracks	Railway track			Railway track	
Water network	River and stream	Stream, torrent or creek			Stream	
Objects	Natural object	Tree or a group of trees			Tree or a group of trees	
Structure	Building	Church			Parish church (protestant)	

area selected for this comparative study. There are geographic differences too, notably for Warsaw the presence of a "lake," as well as cultural differences. The "stadium" at Coventry created at Barkers Butts was not completed by the time of the first edition 1:2,500 scale map in 1889, so again, taking a broader temporal sample will yield variations in the presence of objects. It is a complicated picture that emerges from this. The timing of the maps used for the application of the object analysis is a factor to be considered, as well as cultural variations. This was especially striking in relation to religious buildings, which for the Coventry exemplar include Protestant churches, chapels, and meeting houses of various denominations, but no synagogue or Orthodox church. Fundamentally, Warsaw and Coventry have particular characteristics relating to their histories and geographies that either require a very flexible and expansive ontology, or one that is more narrowly defined, with the flexibility offered at the "lower" ontological levels under the headings of "object" and "sub-type." At the higher levels there are convergences and conformities. This in itself is useful.

Understandably, this all points to the need for further development and application of UrbanOnto and the table of objects, expanding the application to a wider sample of large-scale maps, to see where there are gaps as well as to find objects that seem to have a wide presence. This process also indicates gaps in the UrbanOnto model. One object identified on both maps, for example, but not present in the ontology is the town hall in Warsaw and Coventry. Undoubtedly, it is but one of the types of objects that will need to be added to a future version of the ontology. It is also problematic that various road categories are not fully developed in the UrbanOnto ontology, which means that the types identified on the map, such as a "szosa" (chaussee) or a "trakt,"[36] are "lost" when trying to map the contents of the map to the ontology.

In sum, then, based on the described above exercise of mapping objects from two different historic cartographic sources to UrbanOnto, the following advantages are evident. First, ontology could be used for a structured analysis of the source content, when the source itself has no legend. Consequently, an ontology might be used to reconstruct the legend of the map or plan. Due to the (partially) hierarchical structure, an ontology could also be used to compare the level of detail of two cartographic sources (without an intrinsic legend). Therefore, an ontology could serve as a bridge or a link between two (or more) different sources or publications. Second, moreover, when using the tool that structures the basis of the analysis – the content of the map – these can be publications from various periods or distant areas. What is more, an ontology could be treated as a secondary (derivative) legend of the cartographic materials. Thus the model from the ontology can be used as the controlled dictionary of terms, which allows to annotate maps (e.g. in GIS environment) with more detailed information on urban space in a structured way. Thirdly, ontology can also be useful in standardising research using (spatial) databases. In order to facilitate the entering of objects into the database, one might find it worth mapping the symbols from cartographic sources to the ontology beforehand.

There are of course also methodological limitations in using ontologies to work with old maps. Firstly, the ontology might not fully reflect the typology of the map content. For example, on many maps the distinction between building materials or the importance of the object are presented. UrbanOnto's ontology, on the other hand, focuses on the functions of objects. Secondly, a further problem is mapping one model of reality (ontology) to a different model (map), an issue which is also discussed in this book by Eide[37] and Katarzyna Słomska-Przech and Wiesława Duży.[38]

Conclusion and critical reflections

What this study demonstrates clearly is the importance of historic urban mapping not just as a source of topographical and morphological analysis, but also as a basis for exploring urban ontologies. This scale of town-map is widely used across Europe, with examples from the 19th and 20th centuries providing scope for furthering this investigation. Of course, mapping at the scale of 1:2,500 is also key to the European historic towns atlases, and this also offers a major opportunity for furthering our application of this approach to other geographical contexts. From this paper's findings, we recommend especially focusing on maps at this scale in urban ontological analyses and models. Taking into consideration all advantages and disadvantages of working with the ontology, we think that it is worth harmonising the data from different time periods in order to conduct systematic studies of urban space through history. The work on a larger scale can positively contribute to comparative studies of cities. The key issue is the consistency of understanding of concepts by researchers from different countries, and this consistency can be achieved through ontology. Systematic work on the extension of the ontology with objects from the past shows which objects are no longer present in urban space(s), and enables the study of the continuity of objects as well as the continuity of spatialities.

Our last observation concerns what J. B. Harley identifies as the "silences" on maps.[39] Maps are always subjective, partial, and selective in what they show and how. They are culturally embedded and socially constructed and require careful treatment. They cannot be taken, of course, as "objective" reflections of "reality," and with this in mind, we need to think critically, too, about not just what is on the map but what is *not* on the map. This has implications for using historic maps, or indeed any maps, for constructing urban ontologies, for the results will be influenced by the sources used. As well as the "tangible" features that topographic maps help visualise and make visible, what about the "intangible" aspects of urban spaces? To this end the challenge is to draw in maps, of various kinds, to refine our urban ontologies. A first step in this regard has already been done, by including the OntoHGIS ontology with types of administrative units into the UrbanOnto system.[40] Yet as Henri Lefebvre and other theorists have argued, the city and its spaces are as much *lived* as represented, so we need to add into the mix other kinds of cartographic representations of "the urban," maps of perceived spaces as well

as conceived for example, and only then will our ontologies become more a reflection of the spatial complexities of those urban places that we seek to understand ontologically.[41]

Notes

1 Henri Lefebvre, *The Production of Space*, trans. Donald Nicholson-Smith (Oxford, Blackwell, 1991), p. 85.
2 M. R. G. Conzen, "The use of town plans in the study of urban history," in *The Study of Urban History*, ed. H. J. Dyos (London 1968), pp. 113–30.
3 Dietrich Denecke, "Comparative Approaches in the Historico-Topographical Analysis of Towns and Cities," in *Lords and towns in medieval Europe: The European Historic Towns Atlas project*, ed. Howard B. Clarke and Anngret Simms (London: Taylor & Francis, 2015), pp. 33–61.
4 Michael R. G. Conzen, *Alnwick, Northumberland: A Study in Town-Plan Analysis* (London: George Philip, 1960), p. 4.
5 For more on this see Matthew H. Edney, *Cartography: The ideal and its history* (Chicago: The University of Chicago Press, 2019).
6 Cf. titles of papers from "Polish Cartographical Review" and "Polski Przegląd Kartograficzny" in *BIBLIOTEKA Polskiego Przeglądu Kartograficznego. Tom 4. POLSKIE PIŚMIENNICTWO KARTOGRAFICZNE* 1968–2020, ed. Zenon Kozieł (Toruń – Warszawa: Wydawnictwo Naukowe UMK, 2021).
7 Stanisław Pietkiewicz, "The evolution of the map definition during the last hundred years," *Actes du XI Congres International d'Histoire des Sciences, Varsovie-Cracovie*, 1965/4 (1968), pp. 272–275.
8 For more on the map as a model, and maps with and without a legend, see Øyvind Eide, "Modelling as a bridge between maps, spatial concepts, and the territory", in this volume. (pp.**–**).
9 Hereinafter the map will be referred to as the Lindleys' Map, see K. Słomska-Przech, Lindleys' Map of Warsaw (1:2,500) as a tool for understanding the urban space preservation, Studia Geohistorica (2023).
10 E.g. see: Richard Oliver, *Ordnance Survey Maps: A Concise Guide for Historians*. Third Edition (London: The Charles Close Society 2013).
11 Magistrat m.st. Warszawy, Rocznik Statystyczny Warszawy 1921–1922 [Statistical Yearbook of Warsaw 1921–1922]. Warszawa: "Drukarnia Krajowa'," 1924, p. 14 (in Polish). From Biblioteka Główna Województwa Mazowieckiego [Main Library of the Mazowieckie Voivodeship]. https://mbc.cyfrowemazowsze.pl/dlibra/publication/edition 14967?id=14967&from=publication
12 W. B. Stephens, "The City of Coventry: Introduction," in *A History of the County of Warwick: Volume 8, the City of Coventry and Borough of Warwick*, ed. W B Stephens (London, Victoria County History, 1969), pp. 1–23. British History Online. http://www.british-history.ac.uk/vch/warks/vol8/pp1-23 [accessed 24 May 2023].
13 For more on the UrbanOnto ontology, see Chapter 7 by Słomska-Przech, Duży in the book.
14 The European Historic Towns Atlas series is examined elsewhere in the current volume, both in the Introduction and the contribution by D. Stracke, M. Słomski, A.-L. Schumacher (Chapter 6).
15 HTA Warsaw will be developed in the project "Historical survey maps and the comparative study of the functionality and morphology of urban space. Standardisation – Digital processing – Research" (BEETHOVEN 4 funding programme; DFG and NCN, 2022–2025).
16 Ryszard Żelichowski and Paweł E. Weszpiński, *William Heerlein Lindley. Plan Warszawy 1912. Plan niwelacyjny miasta Warszawy. Zdjęcie pod kierunkiem Głównego*

Inżyniera W.H. Lindleya [William Heerlein Lindley. Plan of Warsaw 1912. Leveling plan of the city of Warsaw. Survey under the supervision of Chief Engineer W.H. Lindley] (Warszawa: Muzeum Warszawy, 2016) (In Polish).

17 The map series is held in the State Archive in Warsaw. Archiwum Państwowe w Warszawie [State Archive in Warsaw], sign. 72/1001/0/0734R, sheets 1–22.

18 Marek Witecki, 1990, *Plan Warszawy Lindleya 1883–1915 ze zbiorów Archiwum Państwowego m.st. Warszawy [Lindley's plan of Warsaw 1883–1915 from the collection of the State Archives of the Capital City of Warsaw Of Warsaw]* (Warszawa: Muzeum Techniki, 1990) (In Polish).

19 Ryszard Żelichowski, *Lindleyowie. Dzieje inżynierskiego rodu [The Lindleys. The history of the engineering family]* (Warszawa: Oficyna Wydawnicza RYTM, 2002) (In Polish), p. 353.

20 Żelichowski and Weszpiński, *William Heerlein Lindley*, 176.

21 Tomasz Panecki, "Koncepcja struktury bazy danych historycznych obiektów topograficznych" [The Concept of Historical Topographic Objects' Database] (PhD diss., University of Warsaw, 2018), p. 176. https://depotuw.ceon.pl/handle/item/2643

22 "Map of Warsaw," Office of Surveying and Cadastre. https://mapa.um.warszawa.pl/ [accessed 20 October 2022].

23 See: Roger J. P. Kain and Elizabeth Baigent, *The Cadastral Map in the Service of the State: A History of Property Mapping* (Chicago and London, University of Chicago Press, 1992).

24 Tim Owen and Elaine Pilbeam, *Ordnance Survey: Map Makers to Britain Since 1791* (London, HMSO, 1992).

25 For OS County Series at the scale of 1:10,650, see: Humphrey Southall and Paula Aucott, "Naming the parts: identifying key features within the urban landscapes of England and Wales circa 1900," in this volume. (pp. **–**).

26 Keith D. Lilley, "Mapping the medieval city: plan analysis and urban history," *Urban History*, 27.1 (2000), pp. 5–30.

27 For Great Britain, recent volumes of the British Historic Towns Atlas, as well as associated published maps in the 'Town and City Historical Map' series, use historic OS 1:2,500 mapping as a base, as with the recent (2021) Coventry map. https://www.historictownstrust.uk/maps/an-historical-map-of-coventry

28 See: J. Brian Harley, *Ordnance Survey Maps. A Descriptive Manual* (Southampton, Ordnance Survey, 1975), pp. 49–53; see also Owen and Pilbeam, *Ordnance Survey*, pp. 49–51. The use of ["] here to denote "inches," a common abbreviation used in cartography drawn to imperial scales.

29 Harley, *Ordnance Survey Maps*, pp. 52–53.

30 Owen and Pilbeam, *Ordnance Survey*, p. 54.

31 Harley, *Ordnance Survey Maps*, pp. 56–58.

32 Harley, *Ordnance Survey Maps*, Appendix 4.

33 https://maps.nls.uk/view/128076891

34 Harley, *Ordnance Survey Maps*, p. 63.

35 https://maps.nls.uk/transcriptions/edinburgh/help/

36 "Trakt" is a type of a road, usually a main route leading from one town in a direction of another, it might be a road used by post or main trade route for the area. Mainly roads in eastern part of Polish territory and further to East were named "trakt."

37 Eide (pp. **–**).

38 Słomska-Przech & Duży (pp. **–**).

39 J. Brian Harley, *The New Nature of Maps: Essays in the History of Cartography: Essays in the History of Cartography* (Baltimore, Johns Hopkins University Press, 2002).

40 More on that in the chapter by Katarzyna Słomska-Przech and Wiesława Duży.

41 Keith D. Lilley, "Conceptualising the city. Historical mapping, spatial theory, and the production of urban spaces," in Michel Pauly and Martin Scheutz (eds.), *Cities and their Spaces. Concepts and their use in Europe* (Städteforschung, Münster, 2013), pp. 29–40.

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9 Changes in spatial development of Lviv from the second half of eighteenth century to the present day

Marta Demchyna, Katarzyna Słomska-Przech, and Tomasz Panecki

Introduction

Geographic information systems (GIS) and transferring old maps to digital versions facilitate conducting historical and geographical research. GIS helps scholars to gather, analyse, and visualise spatial data and thusly increases the effectiveness of urban spaces analysis, including changes that took place in that space over time.

The goal of the chapter is to study changes in the spatial development of Lviv in four time snapshots from the town's history with the usage of GIS. In the analysis we take into account old maps and plans, as well as modern geographical data. The goal of the chapter is divided into three sub-goals: methodological, application, and cognitive. The application goal is to prepare uniformed maps based on three selected old maps from different historical periods, and a map of modern Lviv based on OpenStreetMap (OSM) data. The methodological objective is to test and then implement a methodology for the integration of OSM data and old plans, as well as to harmonise data into the structure of the Topographic Object Database (Polish: *Baza Danych Obiektów Topograficznych*, hereinafter referred to as BDOT10k) along with UrbanOnto ontology. Achieving the cognitive aim consists of assessing changes in the spatial development of Lviv from the second half of the eighteenth century to modern times on the basis of the prepared maps mentioned above. In addition to a quantitative analysis, we will conduct qualitative examination of differences in the perception of topography based on selected cases within the studied periods. Work presented in this chapter was one of the first applications of the UrbanOnto ontology.

Related studies

Historical GIS

Historical GIS (HGIS) is a research approach towards historical data based on the GIS that stems from geographical analysis.[1] HGIS is part of historical geography and explores new opportunities in this field. It may lead to a significant shift in historical scholarship by introducing the use of GIS software, collecting spatiotemporal data in databases, and visualising data with maps.[2] The main issues addressed

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by HGIS are land use and land cover changes, reconstruction of historical settlements and administrative boundaries, and studying past landscapes.[3]

The usage of HGIS could be divided into three stages: data collection, analysis, and visualisation.[4] In the process of HGIS studies, data collection comprises of georeferencing old maps and developing spatial databases through the vectorization of an old map. Georeferencing is the process of converting a scanned raster map image into a numerical raster map with geographic coordinates and a specific frame of reference.[5] In HGIS-related work, one usually deals with large spatial data sets, which are maintained primarily in databases, that facilitate teamwork and enable the development of these data outside of GIS software.[6]

The advantage of GIS data is the combination of attribute and spatial information, which allows for complex spatial analysis. According to Gregory and Ell, the task of spatial analysis is most often to look for differences between the studied areas.[7] On the basis of GIS data, we can examine selected spatial elements, their dimensions (length, field, etc.), and the surroundings.

Old maps are one of the most important sources of data in HGIS studies. When comparing changes in space, all sources must have a comparable range of content[8] and similar scale. Map scale affects the degree of generalisation, which influences research results. It is also crucial to match appropriate, representative time intervals.[9]

Decisive problems that could be encountered during HGIS studies are related to data precision, granularity, and nature. Precision depends on many factors. To mention some of the most basic ones, let us list the quality of old maps, scans, and photos. It is also worth adding that the accuracy of historical data decreases as we go back to the past.[10] The problem of data granularity could be viewed from two different perspectives. In the case of very detailed data, generalisation is necessary, i.e. it is indispensable to select the most crucial elements on the map, at the expense of omitting those of lesser importance. On the other hand, the detailed data will most likely not be useful. The nature of old-map data is determined by the fact that maps do not depict actual measurements, but one of the possible interpretations of reality made by the author of a given map.[11] The next section describes examples of HGIS projects with focus on analyses that could be performed on the basis of historical data and their visualisation.

HGIS in urban studies

The most important project in the context of this chapter is the European Historic Towns Atlas (HTA), led by the International Commission for the History of Towns.[12] The aim of the initiative is to develop atlases of towns for comparative research.[13] Each HTA volume contains a descriptive and cartographic part, which is in turn made up of not just a selection of old maps, but also vedutes and thematic maps.

In the future, researchers involved in the project plan to develop a spatial database for towns, which would facilitate access to historical data and allow for a comprehensive analysis of urban space, also in comparative terms.[14] By 2020, 581

atlases of towns from 20 European countries were published.[15] The Ukrainian Historic Towns Atlas project is part of a pan-European project. Up to the end of 2022, five volumes of Ukrainian HTA were published (Lviv – henceforth as HTA Lviv, Halych, Zhovkva, Zhydachiv, Belz).[16]

The most extensive study on the spatial development of Lviv at the moment is the first volume of the Ukrainian HTA.[17] The atlas encompasses 25 maps, from which the oldest is dated to 1635 ("Situs Leo Poliensis" by Frederik Getkant), and the latest one is from 2013. In addition, the Atlas contains 11 thematic maps (e.g. spatial development of Lviv in various periods, fortifications, and location of sacred buildings). In the descriptive part, authors covered the periods from the early Middle Ages to modern times and described in detail the historical and urban development of the city in particular time intervals.

From the perspective of the efforts discussed in this chapter, it is important to mention web maps, one of the most user-friendly ways to visualise HGIS data. Projects to develop such maps have been and are being carried out for many European towns, including Florence or London,[18] also as a part of HTA projects like Coventry for British HTA[19] and Dungarvan or Galway for Irish HTA.[20]

A web map is also being created for Lviv as part of "Lviv Interactive," which is centred on the town's history from 1500 to 2018.[21] The map is significantly different from those presented above. First of all, the base map is not an old map, but a Google Map. Secondly, the project does not strive to show a snapshot of Lviv during a selected period of time, but aims to showcase the city's evolution over time while considering the impact of these transformations on the contemporary image of Lviv. A wide range of available data enables analysing changes in building function, tracing the story of selected objects, and examining various aspects of social life.

One of the issues that HGIS deals with are changes in the development of towns in terms of both quantitative and visual qualitative comparative studies. Such analyses are carried out on the basis of at least two old maps from different historical periods. One example of such work is the book by Kociuba on the city of Lublin from the Middle Ages to the present day.[22] Kociuba presented a number of maps showing the spatial development of Lublin with focus on changes in boundaries. Another example is the work of Podobnikar, who focused on the development of the railway network in Ljubljana and changes in the course of the Ljubljanica River.[23] For Lviv, Cegiełko and Karsznia analysed some aspects of the city in the years 1932–2016.[24] The aim of the study was to analyse the age of buildings and changes in their functions, as well as to investigate any rerouting of tram lines. The results of the study were presented in a number of thematic maps.

Research area and materials

We conducted the analysis based on four old maps (1776, 1844, 1855, and 1918) and modern geographical data (2020). We harmonised all collected data to the BDOT10k model and thus to the UrbanOnto ontology.

Maps

1766 Map

The earliest map comes from the period before the first partition of Poland (1772), when Lviv was part of the Polish-Lithuanian Commonwealth.[25] All the main fortifications were constructed at that time. Buildings from this period include, for example, the City Arsenal or Benedictine Church.[26]

We chose the "Plan de la Ville, des Chateaux et des faubourgs de Leopol…" (1:24,000) from 1766 (hereinafter referred to as the "1766 Map") to present Lviv of the first examined period.[27] It is the earliest known map, which was not prepared for military purposes. Most presumably, it was the first large-scale cadastral map of Lviv.[28] It presents roads, buildings, greenery (including parks, forests and gardens), hydrographic objects (rivers, ponds and lakes) as well as representations of the terrain and fortifications.[29]

1844 and 1855 maps

After the first partition of Poland, Lviv became part of Austrian lands. To a large extent, the city owes its present appearance to this period. At that time, today's Lviv University, Polytechnic, and many houses in the central part of the city were built.[30] In 1820, town walls were finally removed, which allowed for the integration of the centre with suburbs.[31] In 1861, the first railway line was built, connecting Lviv with Krakow and Vienna.[32]

Our first choice to present Lviv in the second analysed period was a map from 1844 ("1844 Map," 1:7,200).[33] After partial vectorization, it appeared that the source proved difficult to interpret, especially in terms of greenery classification. Therefore, we decided to work with the source from 1855 ("1855 Map"). This is a printed map (1:10,800), so it is more legible and thus easier to vectorize. In addition, the map has a legend, with separate symbols for types of built-up areas, public and sacral buildings, and different forms of greenery. A big advantage of the 1855 Map is that it shows the above-mentioned railway. However, after georeferencing the 1855 Map, it turned out that its range was not fully convergent with the designated area of analysis, so we used the 1844 Map to complete the missing parts (the research area is described in detail in Section "Selection of the research area").

1918 Map

The shortest of the studied periods was the interwar period (1918–1939), when Lviv once again formed part of Poland.[34] At that time, the territory of the town expanded and Lviv was the third largest Polish city after Warsaw and Łódź.

In order to analyse Lviv in the interwar period, we chose a map published ca. 1920 (1:20,000). However, the map presents Lviv as of 1918 ("1918 Map"). This is the only map used in the study that does not come from the Lviv HTA volume,

but is available at the MAPSTER website.[35] The map presents road, rail and hydrographic networks, buildings, cemeteries, and green areas.

Vector data

The modern border of Lviv

In order to complete work in GIS, we needed a reference layer, i.e. the contemporary border of Lviv in. shp format. During our work (in 2020), Ukraine did not have a publicly available vector database with administrative borders. Thus, finding the reference layer turned out to be a challenging task. Verification of the borderline caused difficulties, as various sources (OSM, GoogleMaps, United Nations, Lviv's official website) presented different courses of the border. After thorough search, we decided to use the shapefile with administrative division of Ukraine from 2018 from the Humanitarian Data Exchange (HDX) database maintained by the UN Office for the Coordination of Humanitarian Affairs.[36]

OpenStreetMap

We have chosen to use the OpenStreetMap data to present contemporary Lviv.[37] In the OSM database, which is built using wiki technology, each object is described by a label consisting of a key and a value (key=value, e.g. waterway=river).[38] As OSM is created by volunteers, the data may not meet standards commonly applicable to geographical information (*inter alia* completeness, consistency, accuracy).[39] Hence the problem of verifying the quality of OSM data.[40]

We considered two potential sources of data – Geofabrik service and QuickOSM (QGIS plugin)[41] – for which we analysed both visual aspects, as well as attribute tables. It turned out that the data from Geofabrik[42] were incomplete, since many important buildings were missing (e.g. Lviv Polytechnic, National Museum). The contents of the attribute tables also differed in favour of QuickOSM.

The process of retrieving data using the QuickOSM plugin consisted of entering the key and value, as well as specifying the area. We selected layers for download based on an initial analysis of the feature classes from old maps. First, we attempted to retrieve layers according to these classes using both keys and values. One of the retrieved layers were important buildings, which on the old maps included i.a. universities. However, it turned out that the downloaded data (label "amenity_university") represented campuses as a whole (without a division into buildings, greenery, etc.). Similar inconsistencies occurred for other layers. As the first method was not successful, we decided to retrieve six general layers only by key ("buildings," "landuse," "natural," "highway," "railway," "waterways"). Then, we extracted each feature to separate layers using the information from the attribute table.

Topographic Object Database

The Topographic Objects Database (BDOT10k) is a model of geographical space representing "selected terrain objects, topography, and additionally selected social and cultural objects."[43] The BDOT10k model distinguishes objects on the basis of the physiognomic criterion. The data is classified at three levels of detail (from the least to the most detailed): categories of object classes (lowest), classes of objects (medium), and object types (highest). There are nine main categories in BDOT10k: "water network," "communication network," "utility lines," "buildings, structures and equipment," "land use," "land cover," "protected areas," "administrative units," and other "objects."[44]

Methods

The procedure, presented in this chapter, allows for integrating different types of spatial data (old maps and OSM) and harmonising them into the structure of the BDOT10k and the UrbanOnto ontology. The following subsections discuss: selection of the area, map georeferencing, legend reconstruction, database design, map vectorization, OSM data generalisation, development of a common legend,[45] and maps.

Selection of the research area

After collecting all the data, our first step was to select the area of analysis. We considered two possible levels of the study: 1) analysis of the area located within the modern border of Lviv (scale ca. 1:100,000), 2) focus on the city centre (scale ca. 1:20,000). After inspecting the extent of the old maps, we selected the second option, which we considered to be more suitable (Figure 9.1).

We have chosen the area based on a map from HTA Lviv (hereinafter referred to as "Map 3.1.")[46] presenting spatial development of Lviv from the thirteenth century to the beginning of the twenty-first century. We decided that the scope of analysis would be the same as the area within the border of the urban spread development from 1766 (hereinafter referred to as "1766 Border").

Maps georeferencing

We georeferenced all maps in QGIS 3.16.1. The reference layers were buildings, roads, and railways from previously downloaded OSM data. We used information on the age of selected buildings from the "Lviv Building Age Map."[47] Map 3.1. was georeferenced to the modern border of Lviv. All maps, except the 1766 Map, were subject to affine transformation (Table 9.1). After georeferencing the 1766 Map with the affine transformation, it turned out that the error was very high (over 32 pixels). Thus, we decided to georeference the 1766 Map with the spline transformation, as it resulted in lower error, and better visual consistency with the reference layer.

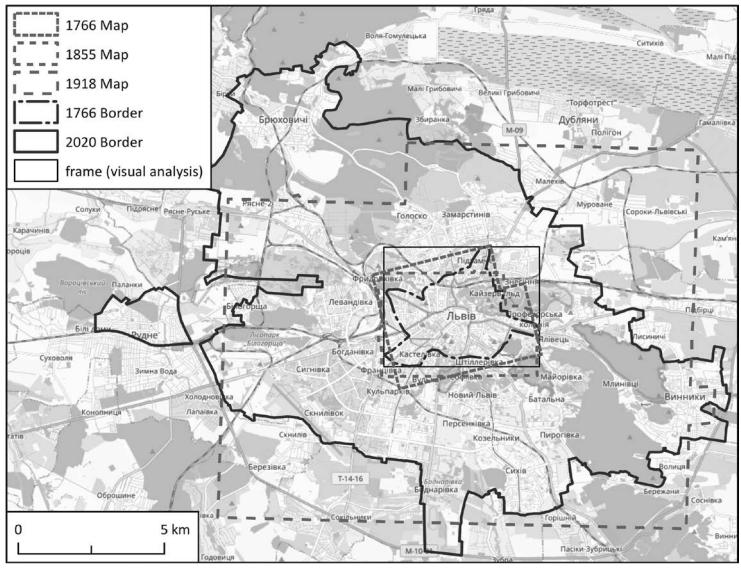

Figure 9.1 Scope of old maps, analysed areas, and the modern border of Lviv (basemap: Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org; https://www.openstreetmap.org/copyright).

Maps scope of content reconstruction

Before designing the database, it was necessary to reconstruct the scope of content (legend, key to symbols) for the 1766 and 1918 Maps. Although the 1766 Map had a numbered list of objects and streets, these numbers do not appear on the map itself. The 1918 Map had no additional descriptions. In addition to visual analysis, the symbolization used on the maps was compared to the symbolization of other maps with legends from similar periods.

We found it difficult to reconstruct the legend of the 1766 Map. The factors hindering the reading of the map were primarily the age of the map, its quality, and colour range – with the prevalence of shades of brown. However, we found it easy to distinguish sacred buildings, important buildings, built-up areas, streets, and water courses.

Table 9.1 Type of transformation, number of points, and transformation error for five maps used in the study.

Map	*Transformation type*	*Number of points*	*Transformation error (in pixels)*
1766	spline	15	2
1844	affine	10	8
1855	affine	10	4
1918	affine	10	11
3.1.	affine	10	7

In the case of the 1918 Map, most of the symbols were intuitive. We did not encounter any problems distinguishing between sacral buildings, important buildings, built-up areas, streets, railways, parks, cemeteries, water, rivers, and other classes.

Database design

We designed the database in ArcMap 10.8. We developed feature classes based on the reconstruction of legends and the analysis of old maps (Table 9.2). Despite the fact that the fortification class appears on both the 1766 Map and the 1918 Map, they present different types of objects: "fortyfikacje_1766" are town walls, "fortyfikacje_1918" – remains of defensive ramparts. It was also important to determine the difference between the classes "ogrod" and "ogrod_2" that appear on the 1855 Map. "Ogrod" represents garden beds, and "ogrod_2" – greenery around residential buildings.

For the design of the database, it was also important to precisely determine the OSM layers taken into account ("buildings," "landuse," "natural," "highway," "railway," and "waterways"). Classes from OSM have been mapped and matched to the classes that were present on old maps. From the six layers, objects with OSM labels suitable for specific classes were selected and exported to separate layers one by one (Table 9.2).

Table 9.2 OSM object classes.

Object class original name of class /translation, if needed/	*OSM Label*
budynki_sakralne_OSM /sacral buildings/	building_cathedral; building_chapel; building_church; building_temple
budynki_wyr_OSM /important buildings/	building_college; building_public; building_tower; building_university
cmentarz_OSM /cemetery/	landuse_cemetery
grass_OSM	natural_grass
grassland_OSM	natural_grassland
kolej_OSM /railway/	railway_rail
rzeka_OSM /river/	waterways_river; waterways_stream
ulica_OSM /street/	highway_construction; highway_living_street; highway_pedestrian; highway_primary; highway_primary_link; highway_residential; highway_secondary; highway_secondary_link; highway_tertiary; highway_tertiary_link; highway_unclassified
woda_OSM /water/	natural_water
wood_OSM	natural_wood
zabudowa_przemyslowa_OSM /industrial buildings/	landuse_industrial

We had to complete more thorough verification of objects in the "budynki_sakralne_OSM" and "budynki_wyr_OSM" classes. When adding objects to the database, OSM users often specify a label key, but do not point to a value or add only a "Yes" value, which results in the function of the object being unknown. During the analysis of the attribute table, it turned out that some buildings (e.g. theatres or universities) with a label "buildings_yes" had the column "name" filled. In these cases, we manually added the object to the appropriate layer.

We also had to verify the layer "rzeka_OSM." From the mid-1880s to the mid-1920s, work on the sewage system and covering of the Poltva River was carried out. During analysis of the OSM data, we noticed that the fact of channelling the riverbed was not taken into account and the river was shown on the surface. However, after reviewing the online OSM map, it turned out that the river in the studied area is marked with a dashed line, explained in the legend as a tunnel, which means that the river continues to run through an underground riverbed. Therefore, we decided that the "rzeka_OSM" class should be removed from the database, as it did not actually appear on the surface.

Beyond the above specified classes of OSM, we have also added classes: "zabudowa_zwarta_OSM," "zabudowa_luzna_OSM," "plac_OSM," and "sciezka_OSM." Table 9.3 provides a complete list of the classes included in the analysis. On top of the classes from old maps and OSM, two classes have been added to define the area of study.

Vectorisation of old maps and generalisation of OSM

We conducted vectorisation of old maps and generalisation of OSM in ArcGIS 10.8. So as to ensure correct vectorisation, we started with the street network. We made the assumption that all surface layers are continuous, so we snapped them to linear layers and other surface layers.

We also had to generalise layers obtained from OSM, to take into account the scale of old maps and plans. The generalisation of OSM data concerned the following layers: "zabudowa_zwarta_OSM," "zabudowa_luzna_OSM," "sciezka_OSM," and partially "wood_OSM," "grass_OSM," and "kolej_OSM." Due to the fact that OSM contained data on buildings, and the study took into account the built-up areas, the surface occupied by the buildings was generalised manually.

To perform the correct generalisation, some classes needed additional assumptions. We established the rules based on the analysis and in relation to old maps. Wherever the object was smaller than the assumed size, it was not taken into account. For the class "plac_OSM," we estimated that it should be at least 30 m wide. For objects from classes "wood_OSM," "grass_OSM" and "woda_OSM," a minimum size of 40 by 40 metres or an area of at least 1,600 m^2 was taken into account. In the case of the "wood_OSM" and "grass_OSM" classes, the generalisation consisted in combining the objects of these classes located close to each other or their possible snapping to the linear layers. In addition, objects from the "zabudowa_przemysłowa_OSM" and "cmentarz_OSM" classes were snapped to the streets.

In order to increase the readability of the map developed on the basis of OSM, we assumed that the "sciezki_OSM" class would include only objects located in cemeteries, main parks, and near the Lviv Opera, and we manually selected

Table 9.3 Database structure and common legend.

1766 Map	*1855 Map*	*1918 Map*	*OSM*	*Common legend*	*b: BDOT10k; o: UrbanOnto*
budynki_ sakralne_1766	budynki_sakralne_1855	budynki_sakralne_1918	budynki_sakralne_OSM	Buildings intended for religious worship and religious activities	b
budynki_ wyr_1766	budynki_wyr_1855	budynki_wyr_1918	budynki_wyr_OSM	• Publicly accessible cultural facilities • Buildings of schools and research institutions • Other non-residential buildings not mentioned elsewhere	b
plac_1766	plac_1855	plac_1918	plac_OSM	Square	b
sciezka_1766	sciezka_1855	sciezka_1918	sciezka_OSM	Pathway	b
ulica_1766	ulica_1855	ulica_1918	ulica_OSM	Street	b
woda_1766	woda_1855	woda_1918	woda_OSM	Surface Water	b
zabudowa_ luzna_1766	zabudowa_luzna_1855	zabudowa_luzna_1918	zabudowa_luzna_OSM	One-family housing	b
zabudowa_ zwarta_1766	zabudowa_zwarta_1855	zabudowa_zwarta_1918	zabudowa_zwarta_OSM	Multi-family housing	b
	cmentarz_1855	cmentarz_1918	cmentarz_OSM	Cemetery	b
	kolej_1855	kolej_1918	kolej_OSM	Railway track	b
las_1766	las_1855	las_1918		Forest	b
park_1766	ogrod_park_1855	park_1918		Trees	b
pola_i_laki_1766	pola_i_laki_1855	pola_i_laki_1918		Grasses and crops	b

(*Continued*)

Table 9.3 (Continued)

1766 Map	*1855 Map*	*1918 Map*	*OSM*	*Common legend*	*b: BDOT10k; o: UrbanOnto*
rzeka_1766	rzeka_1855	rzeka_1918		Water network	b
tereny_ zielone_1766	tereny_zielone_1855	tereny_zielone_1918		Trees	b
	zabudowa_przemyslowa_ 1855	zabudowa_przemyslowa_ 1918	zabudowa_przemyslowa_ OSM	Industrial and warehouse buildings	b
	pomnik_1855	pomnik_1918		Statue	b
		wal_ziemny_1918		Earth structure	b
fortyfikacje_1766				Town walls	o
		fortyfikacje_1918		Defensive rampart	-
	krzaki_1855			Shrub	b
	krzyz_1855			A figure, a shrine or a roadside cross	b
	ogrod_1855			Grasses and crops	b
	ogrod_2_1855			Garden	o
	szubienica_1855			Gallows	o
	wiatrak_1855			Windmill (other than a building)	b
	winnice_1855			Grasses and crops	b
	znak_1855			Roadside sign	-
			grass_OSM	Grasses and crops	b
			grassland_OSM	Grasses and crops	b
			wood_OSM	Trees	b
		tereny_podmokle_1918		Wetland	b

these paths. We did not take into account paths along the streets or located in the middle of buildings. In addition to the above-mentioned classes, we also generalised objects belonging to the "kolej_OSM" to improve map legibility.

Developing a common legend

After completing the vectorisation and generalisation of the maps, in the next step we developed a common legend, which was based both on the model of the BDOT10k and UrbanOnto ontology (Table 9.3).[48] We used three types of objects defined in the ontology, i.e. "town walls," "garden," and "gallows." The types proposed to be supplemented in the ontology were "roadside sign" and "defensive rampart." We designed the symbols for the maps of town development based on BDOT10k.[49]

The match between most classes was quite obvious and did not cause problems. However, some difficulties arose when matching the classes of greenery and important buildings. In the case of greenery, after visual and comparative analysis, we combined some classes, for example, class "grasses and crops" included "pola_i_laki," "ogrod," "winnice," "grass" and "grassland," class "trees" contains: "park," "tereny_zielone," and "wood" from the OSM layer.

The difficulty in matching the class "budynki_wyr" was that the very concept of important buildings is quite broad, containing museums, theatres, universities, palaces, etc. After a preliminary analysis of the functions of important buildings, we found that in the designed database the class "budynki_wyr" should be divided into three subclasses depending on the function of the building. We named the following classes: 1) "publicly accessible cultural facilities," 2) "buildings of schools and research institutions," 3) "other non-residential buildings not mentioned elsewhere." We came across the problem of verifying building function on historic maps. The older the source, the more difficult or impossible building function became to determine. Therefore, we assumed that if it was impossible to define, we should include a given building in the last, third class.

Palaces constituted an important issue in our work on identifying important. Due to the inability to verify the function of buildings, it was not possible to ascertain which buildings went on to serve as palaces in subsequent periods. Despite the fact that the main function of a palace is residential, we also included them in the class of "other non-residential buildings not mentioned elsewhere," as it was the most general class.[50]

In some cases, additional verification of the old maps sufficed to establish building function, which was then added to the appropriate class. For a modern map, building functions were determined based on an OSM attribute table.

The "rivers" classes were mapped to superior classes, i.e. "water network." We resorted to this solution, since source materials did not always enable distinguishing clearly between such subtypes as stream, river, or drainage ditch.

Results

One of the main results of the paper are historical maps of spatial development of Lviv (1766, 1855, 1918, and 2020) corresponding to four periods of the city's history: Polish Lviv, Austrian Lviv, Lviv in the interwar period, and modern city (Figures 9.2–9.6).[51]

Figure 9.2 Spatial development of Lviv: 1766.

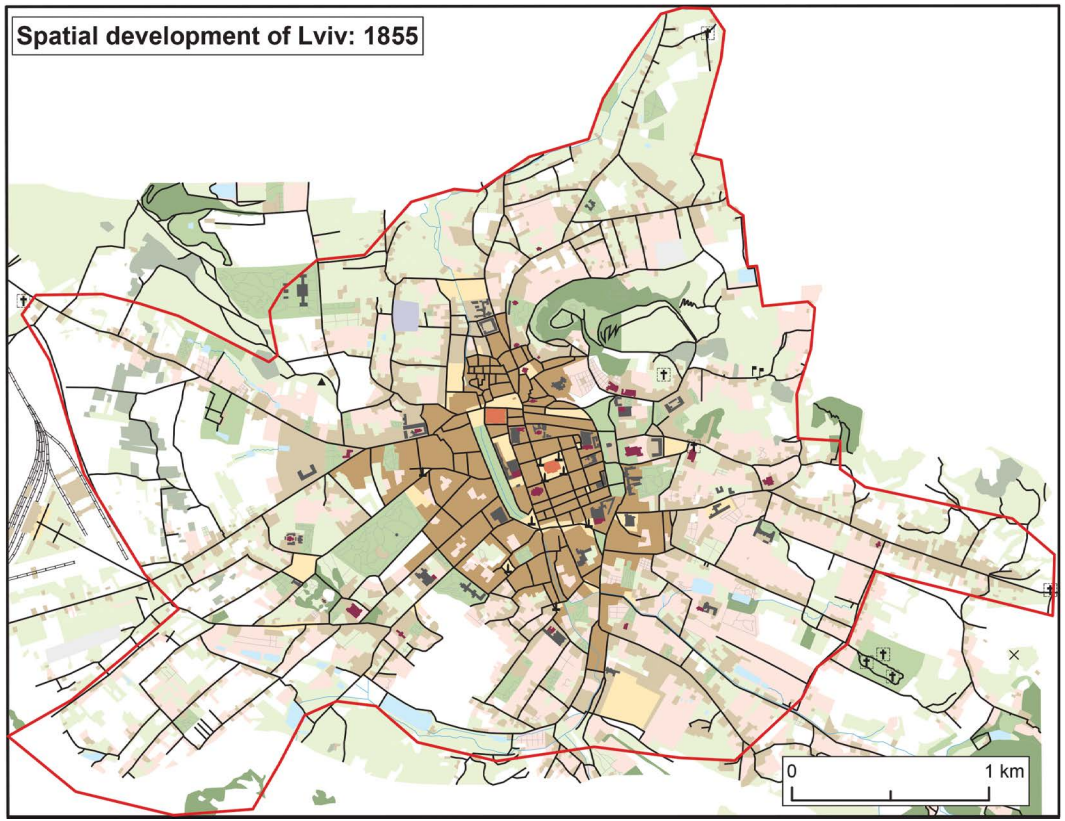

Figure 9.3 Spatial development of Lviv: 1855.

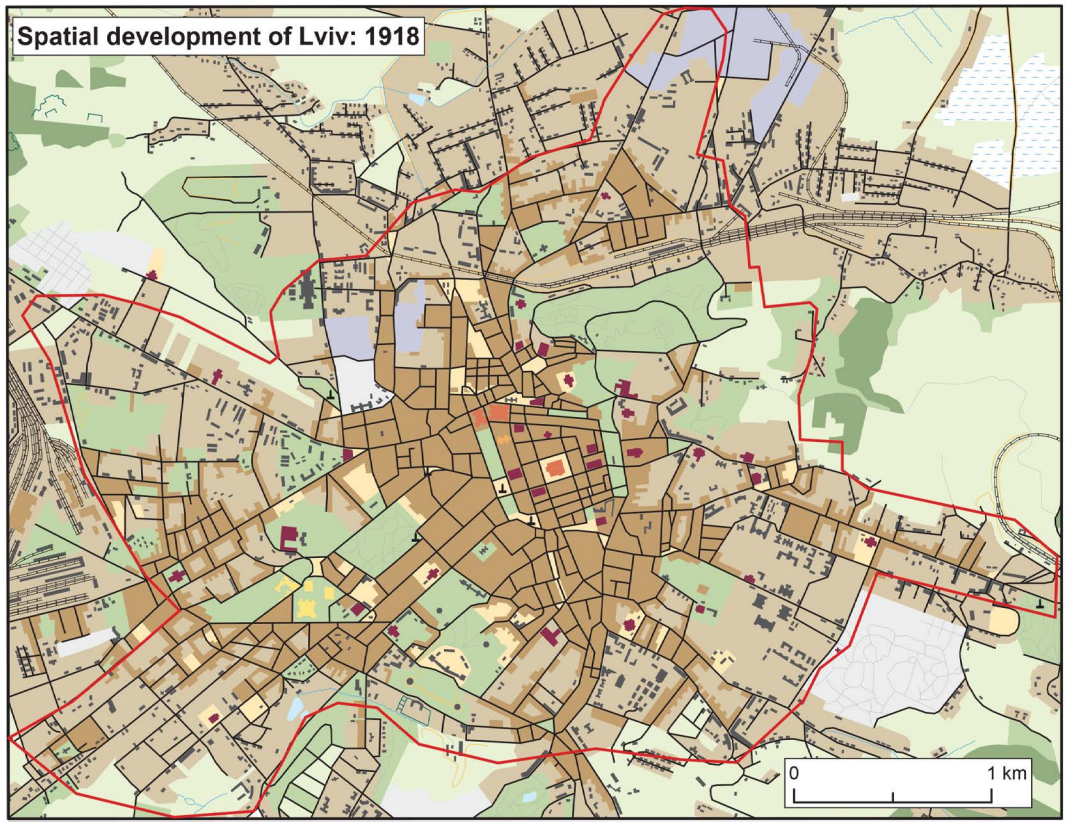

Figure 9.4 Spatial development of Lviv: 1918.

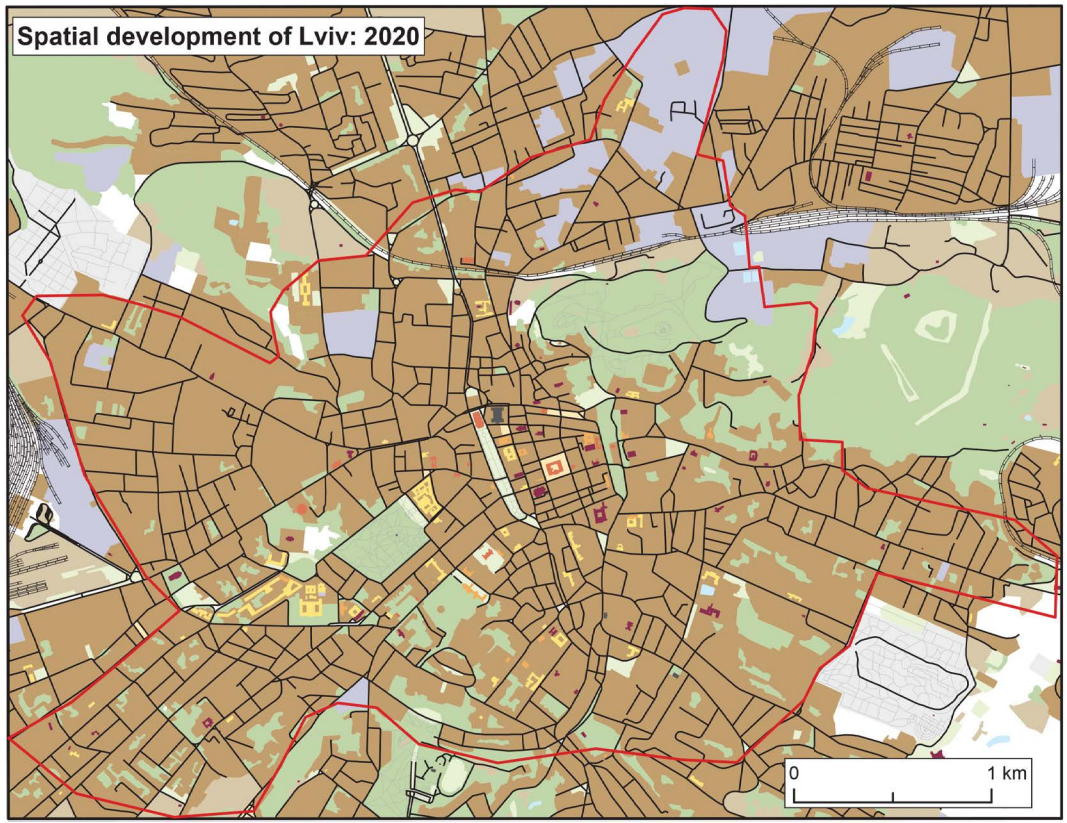

Figure 9.5 Spatial development of Lviv: 2020.

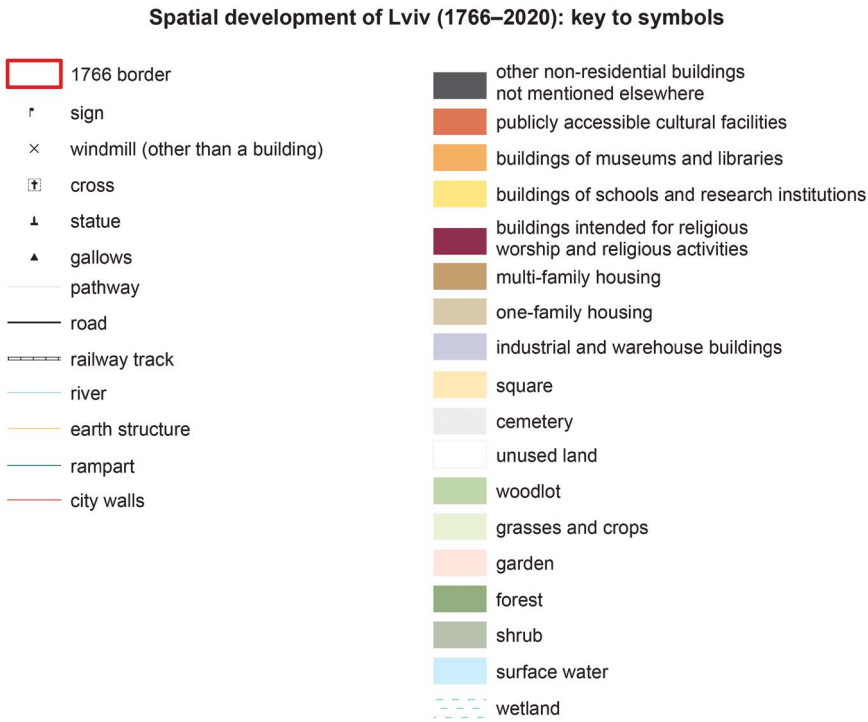

Figure 9.6 Spatial development of Lviv (1766–2020): Key to symbols.

We executed the assessment of changes in the spatial development of Lviv at two levels: 1) area located within the 1766 Border, 2) area in a frame designated for visual analysis (Figure 9.1). We conducted quantitative analysis within the first area, and – due to incompleteness of data outside the 1766 Border – qualitative analysis of the second. In the larger of the areas there were facilities, whose construction and development were significant for the transformation of the city.

Changes in the development of Lviv

Point objects

We devoted most attention to point objects from the 1855 Map, among which one could find such symbols as a roadside sign (2 occurrences), a roadside cross (4), a statue (9), and a gallows (1), as well as a windmill (however, it was located outside the 1766 Border). On the 1918 Map, we found only one type of the object – the statue (6). The 1766 Map does not show any point symbols (Table 9.4).

After analysing data on point objects in the OSM database, we concluded that we should not take them into account on the modern map. The decisive factor was the number of point objects, mainly statues, in the studied area. Due to the fact that

Table 9.4 Number of point objects within 1766 Border.

Point object	*Number of occurrences*			
	1766	*1855*	*1918*	*2020*
Roadside sign	-	2	-	-
Roadside cross	-	4	-	-
Statue	-	9	6	-
Gallows	-	1	-	-

OSM gives any user the possibility of adding data, statues (which were not always properly classified) appeared very close to each other, thus causing visual clutter. Due to such a large number of statues, verification of each object was difficult. It would also be troublesome to choose only the important statues, as any choice would be subjective.

BUILDINGS

Table 9.5 presents the number of buildings with a certain function in subsequent years. Class of "buildings intended for religious worship and religious activities" was the most obvious to represent on the development maps, and it was also easy to distinguish on all old maps. The highest number of such buildings were presented on the modern map of Lviv.

As already mentioned while discussing the development of the common legend (see Section "Developing a common legend"), the objects from the first three classes in Table 9.5, originally belonged to one class, i.e. "important buildings." Taking into account the date of elaboration of the old maps, it was often impossible to verify the exact function of the building. In such cases, the buildings were classified as "other non-residential buildings, not elsewhere listed."

Another interesting issue is what buildings were included in the class of important buildings on analysed old maps. In the case of the maps from 1766 and

Table 9.5 Number of buildings within 1766 Border.

Type of the building	*Number of occurrences*			
	1766	*1855*	*1918*	*2020*
Other non-residential buildings not mentioned elsewhere	59	56	785	4
Publicly accessible cultural facilities	-	2	4	37
Buildings of schools and research institutions	-	-	6*	69
Buildings intended for religious worship and religious activities	45	34	33	53

* In the interwar period, Lviv was an important educational centre. There were 14 public gymnasiums and several private schools in the city. However, in our analyses we take into account only the beginning of this period and the area within the 1766 border. Karol Sanojca, "Miejsce Rodziców w Życiu Lwowskich Szkół Średnich w Okresie Międzywojennym," *Wychowanie w Rodzinie* 19, no. 3 (2018): pp. 73–91, https://doi.org/10.34616/WWR.2018.3.73.91.

1855, there were relatively few of these buildings. Although it was not possible to determine their exact function, these buildings were significant in town space, e.g. they housed museums, libraries, or palaces. On the other hand, on the 1918 Map, authors used the same sign for both the important buildings and all the buildings that most likely had a function related to agricultural or manufacturing activities. For this reason, on a map presenting the state of play from 1918, we assigned 785 buildings to the class of "other non-residential buildings not mentioned elsewhere," which in comparison with other old maps is more than 13 times more. Taking into account the difficulties described above, the number of buildings from the first three classes in Table 9.5 should be perceived as illustrative data, as they cannot be used for precise analyses.

Linear objects

Table 9.6 contains data on the lengths of linear objects within the 1766 Border. Analysing the data on the length of streets, we observed that the street network in subsequent studied periods developed systematically (between three first periods for about 25 km). In total, from 1766 to 2020, the length of the streets increased by almost 56 kilometres.

The reduction in railway length between 1918 and 2020 results from the generalisation of OSM data. In order to increase map readability, densely arranged railway tracks were removed.

Figure 9.7 presents the constant shrinking of the water network in studied periods. The main reason behind this reduction was the introduction of a sewerage system and covering the Poltva River, which was discussed in detail in the subsection on database design (see Section "Database design"). An additional reason for the decrease in the length of the water network between 1766 and 1855 was the removal of the city walls and defensive ditches around the market square, and the general expansion of the city. In the Figure 9.7, it is clearly visible that in the first studied period the water network surrounded the market square, yet in 2020 this class did not occur at all in the analysed space.

Table 9.6 Length of linear objects within 1766 Border.

Linear objects	*Length in km*			
	1766	*1855*	*1918*	*2020*
Pathway	36.79	36.45	8.49	18.56*
Street	72.72	95.99	121.07	128.32*
Railway track	-	-	4.80	3.26*
Water network	18.06	10.16	1.19	-
Earth structure	-	-	5.16	-
Defensive rampart	-	-	0.56	-
Town walls	9.05	-	-	-

* Data for 2020 from OSM were generalised.

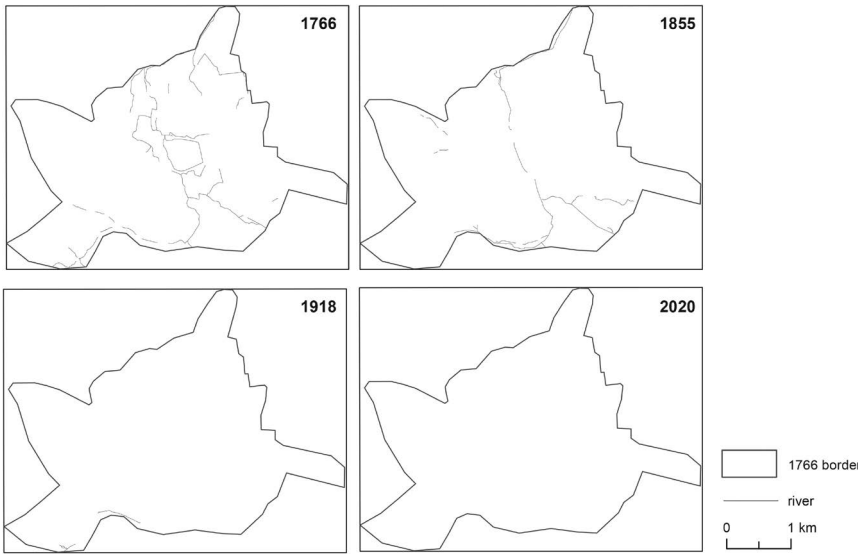

Figure 9.7 Changes in river length.

Surface objects

Table 9.7 presents changes in the surface of land cover and land use. The biggest changes occurred in the classes of built-up areas. New built-up areas appeared mainly around the market square and along the streets. On the first three maps, single-family housing predominates, but we can observe that both the area occupied by one-family and multi-family housing were constantly growing. In 2020, most of the buildings were multi-family buildings (approx. 8 km^2). Industrial and storage buildings first appeared on the 1855 Map. Subsequently, industrial areas sprung up in the north-east of the studied area and in the west, in the vicinity of the railway station.

Table 9.7 Area of land use within 1766 Border.

Type of land use	*Area in sq. km*			
	1766	*1855*	*1918*	*2020*
Surface water	0.17	0.08	0.01	0.01
Multi-family housing	0.27	1.02	3.22	7.95
One-family housing	1.71	1.63	4.46	0.19
Industrial and warehouse buildings	-	0.02	0.18	0.70
Square	0.21	0.26	0.38	0.03
Cemetery	-	0.02	0.09	0.01

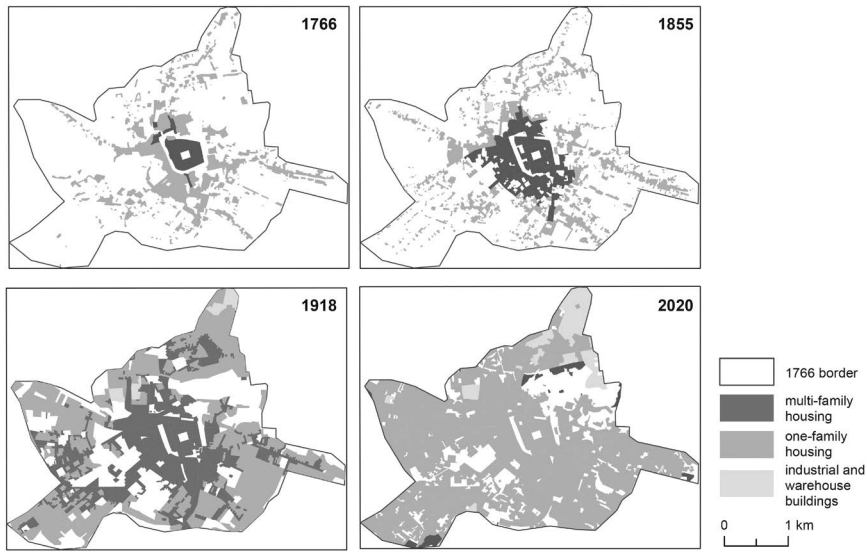

Figure 9.8 Changes in built-up areas.

It is worth emphasising that the shape of the studied area also played an important role in the spread of urban development. Invariably undeveloped remains the area north of the market square where the Lviv High Castle is located (Figure 9.8).

Table 9.8 shows areas occupied by greenery. Some classes disappeared from the analysed area over time. Whilst in 1766 the forest occupied about 1.4 km^2, by 2020 it was nowhere to be found in the analysed area. We observed a similar situation in the case of grasses and crops.

Major changes occur in the ratio of areas occupied by buildings to green areas. In each of the studied periods, there was less and less greenery, while the share of built-up areas was on the rise. Maps from Figure 9.9 present all buildings without division into subcategories and combined types of greenery. In 1766, greenery occupied over 8 km^2, and buildings took up about 2 km^2. On the

Table 9.8 Area of greenery within the 1766 Border.

Type of greenery	*Area in sq. km*			
	1766	*1855*	*1918*	*2020*
Trees	1.23	0.63	1.75	1.61
Grasses and crops	5.69	2.55	0.68	0.30
Garden	-	1.72	-	-
Forest	1.40	0.23	0.004	-
Shrub	-	0.15	-	-
Total	8.32	5.27	2.44	1.91

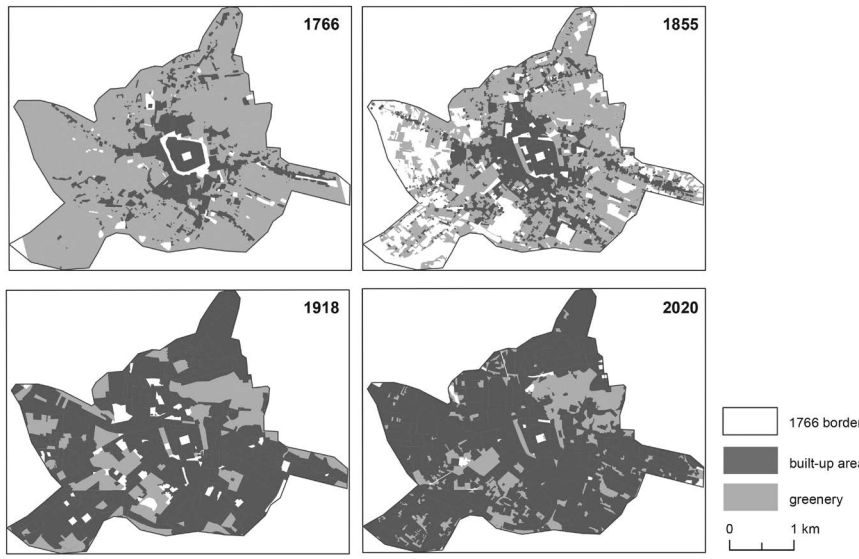

Figure 9.9 Changes in green coverage rate.

map depicting Lviv in 2020, buildings occupied almost 9 km^2, and greenery – less than 2 km^2.

Changes in the perception of topography

After analysing the old maps used in the study, we arrived at the conclusion that depending on the period, authors approached the preparation of maps differently. For each period, we can distinguish types of objects which are specific for a given map, yet are not present in other analysed cartographic sources. For example, terrain is presented on the 1766 Map, and this was the only analysed map that took into account this type of content.

Authors of the 1855 Map paid special attention to the depiction of point objects. Objects such as "statue," "roadside cross," "gallows," "roadside sign," and "windmill" were distinguished. None of these objects, apart from "statue," appear on the other analysed old maps ("statue" appears on the 1918 Map). It is also worth noticing that the 1855 Map presented the most detailed division of greenery classes (eight classes of greenery in total, including forest, "pola_i_laki," "tereny_zielone," "shrub," "vineyards," and three types of garden). In comparison, on maps from 1766 and 1918 there were only four classes of greenery.

It is also interesting that the 1855 Map shows the train station and part of the railway tracks around the building. In fact, construction work started four years later, and was not completed until 1861.[52] A similar situation occurred in the case of the municipal gas plant. The 1855 Map showed the area of the gasworks as a built-up area, despite the fact that the gas plant was built in 1858.[53] Based on the

examples of the station and gas plant, it can be concluded that the authors of the map had knowledge of future urban investments. It is also logical to suppose that the 1855 Map was created later, and was mistakenly dated 1855. This is a matter for future discussion.

What makes the 1918 Map different is that it showed earth structures and defensive ramparts. Earth structures ran mainly along railway tracks, but they also appeared independently of the tracks, for example in the north or northwest of the studied area. To the north of the Janów cemetery, these were defensive ramparts, which were most likely the remains of Cossack trenches.[54] Defensive ramparts also appeared south of the Citadel.

Conclusions

To sum up, in the presented study we achieved three planned goals. We prepared vector layers for three selected old maps, which were then used to elaborate historical maps of spatial development of Lviv in 1766, 1855, and 1918. In addition, a map of modern Lviv was developed on the basis of OSM data. We tested and implemented methodology for integration of data from old plans and OSM (with one, common legend), and harmonisation of this data into the structure of the BDOT10k model and the ontology of the HOUSe project. The developed methodology could be used for future research on development of urban space. We performed analyses of changes in the development of Lviv from the second half of the eighteenth century to modern days. We analysed historical maps in terms of quantitative and qualitative changes. Of course, comparisons of this type always raise the issue that the creators of successive maps may have defined seemingly identical elements of space differently. It is highly likely that some categories were not understood in exactly the same way in 1766 and 2020. Nevertheless, we took efforts to interpret and harmonize the content of the old maps and modern data. As part of the quantitative analysis, we paid special attention to changes in the built-up areas, and to the green cover rate, as well as to changes in the length of the river and street network. In addition, we analysed the number of point objects such as a statues, gallows, roadside crosses, roadside signs, and buildings with a specific function. As part of the qualitative analysis, we focused on presenting changes in the perception of the importance of spatial elements in various periods.

Our work strongly focused on the methodological side of analysis, in order to show the opportunities and constraints which lie behind using (historic) maps as data sources. As it was indicated in the very last section, maps are specific, not generic. Historians of cartography often underline that each map is a product of its times and needs to be addressed individually, as it conveys specific pieces of information, not comparable with other cartographic depictions.[55] On the other hand, historical geographers (including urban scholars) make great use of maps as they are the only source depicting historical townscape.[56] It is therefore crucial to find a framework which could benefit both from historical cartography (maps as social products) and historical geography (maps as sources of data). As shown within this study, a domain ontology could form such a framework. Such an ontology is

not only a set of terms and relations between them, but requires extensive, well-documented data harmonization. Map signs representing particular objects need to be harmonized: mapped into a common data model in order to conduct GIS-driven spatial analyses. Such a procedure simplifies the data, but improves its interpretation. Documenting the procedure by describing the extent of simplifications, mappings, and unifications is crucial.

Acknowledgements

This chapter is based on the bachelor's thesis by Marta Demchyna: "Changes in spatial development of Lviv from the second half of the eighteenth century to the present day." Thesis was defended in 2021 at the Faculty of Geography and Re gional Studies, University of Warsaw (supervisors: Tomasz Panecki, Katarzyna Słomska-Przech).

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