Mapping the Inhabited Urban Built Environment

The Socio-Spatial Significance of the Material Presence of Boundaries through Time

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"One could spend a lifetime on nothing but boundaries.
This would be a worthwhile work."

Edward T. Hall, 1996: viii

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1550s	Refers to the 16th century Winchester time-slice based on the 1550s plans drawn up in Keene (1985)
ANT	Actor Network Theory
BLT	Boundary Line Type
dGPS	Differential Global Positioning System
geoTIFF	Raster image in TIFF format with georeferencing information embedded
GIS	Geographical Information System
ISUF	International Seminar on Urban Form
MM	Ordnance Survey's MasterMap, used as shorthand for the 21st century time-slice of Winchester which is based on it
OS	Ordnance Survey, mapping agency of the UK
OS1872	Refers to the 19th century Winchester time-slice based on the first edition large scale Ordnance Survey town plan published over 1871-1872
PEMY	Economic Foundations of Mayapan project
RMS error	Root mean square error, used for the residual error for georeferencing in ArcGIS

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ABSTRACT

This thesis develops a comparative methodology and research practice enabling the interpretive social study of urban built environments (cross-culturally and diachronically). Its contribution to comparative urbanism is framed specifically as a method for studying the socio-spatial significance of the material presence of the composition of urban form (conceptualised as boundaries) to the interactional process of human inhabitation. This perspective results from formulating a theoretical and conceptual rejoinder to questioning the nature of the role of the built environment as emergent from the human process of inhabiting the world and the functioning of urban life and development. On that basis an empirically operational method (Boundary Line Type (BLT) mapping) for the conceptual remapping and analysis of ground level spatial data on the urban built environment (city plans) is devised, so the comparative socio-spatial study of cities from this perspective through time and across geographical areas and societies or cultures becomes enabled.

This foundational development of a research process and ontology is informed by a material adaptation of a critical realist philosophy of science. The practical and technical implications of executing the mapping process on spatial data of varying nature (archaeological, historical, historically reconstructive, and contemporary maps) are comprehensively worked through. The comparative functional ability of the method is demonstrated by exemplifying two case studies, the cities of Chunchucmil (Mexico, Classic Maya) and Winchester (UK, 16^{th}, 19^{th} and 21^{st} century), on the basis of which two test cases are taken forward for preliminary visualisation and analysis with the aid of Geographical Information System (GIS) techniques. The findings confirm its potential, replicating common expectations about contemporary urban life as well as laying a novel foundation for insights into Winchester's historical development and Chunchucmil's archaeology, from which future research and development can burgeon. These are expected to contribute significantly to the deeper understanding of urban life and urbanisation across past and present urban traditions and provide an improved appreciation of urban alternatives which could inform planning and urban design in the long term.

INTRODUCTION TO THE RESEARCH

The rationale

Living in a time when over half of the world's population resides in cities, a proportion that is expected to grow rapidly, a thorough understanding of this way of inhabiting the world has never been more pertinent. Next to consideration of the ecological sustainability of urban life, social scientific concern with the societies inhabiting urbanised landscapes has understandably been preoccupied with the actuality of city dwelling, current governance, and future planning. Within this temporally narrow scope, the problems we are confronted with as populations build and reside in cities are often regarded as particular to our present day predicament. In addition, this confined perspective results in research efforts being almost exclusively absorbed by cities belonging to a western or globalised urban tradition. It is generally accepted that the design of cities (their physical construction and form) influences the social life in, and subsequent development of, cities, while simultaneously people are quick to point out the apparent inaptitude or inability of contemporary urban design ideas to effectively improve the many issues revolving around urban life. In order to make positive contributions to the continued development of cities and the urban way of life, a better understanding is needed of the relationship between society and space and the nature of inhabiting an environment of our own making. Seen in that light, it is peculiar that urban academic discourse is inclined to such a narrow perspective, ignoring most of the array of known urban possibilities.

Granted, the majority of the non-western or globalised urban traditions are a fixture of the past. Archaeological research teaches us that human beings have manifested a proclivity to urbanise for many millennia and that the resulting settlements took widely varying forms. While the disappearance of these alternative urban forms could be taken as a sign of general inadequacy, archaeological evidence is mounting that demonstrates many such alternatives to have been remarkably resilient, successfully persisting as a city or tradition for numerous centuries. Much of the current global urban tradition finds its roots in the historically compact cities of Europe, but were the Spanish invaders not marvelled by the overall sophistication of the Aztec capital Tenochtitlan? For all previous urban traditions it applied that they, to various degrees of success, accommodated the inhabitation by an urban society, the physical form supportive of the everyday functioning of urban social life. In spite of differing technological and environmental requirements, cities of the past as in the present share that, in all their morphological variety and complexity, they needed to function and that they are part and parcel of the fundamental human process of inhabiting the world. Given the openness of this process it is extraordinary that out of the spectrum of feasible opportunities to manipulate the environment to all kinds of societal organisation, so much resemblance exists amongst protean urban forms.

Despite the acknowledgeable similarities and the essence of the human process cities are produced by, social scientific research on urbanism and urban form appears to exhibit a certain reluctance to overcome the interpretive limitations set by the time-space specific socio-cultural contexts in which cities materialise. In this way the knowledge acquired on urbanisation and urban life remains valid only within the particularity of that context. It cannot be assumed — and indeed such is clear from glancing over urban landscapes other than those roughly pertaining to aspects of global standardisation — that the frameworks and concepts developed within a narrowly focused urban academic discourse are necessarily meaningful for the social study of alternative traditions of building and inhabiting urban form. If a deeper understanding of the functioning of such processes is desired, a comparative approach is needed that is able to tell us about the differences and consistencies both between geographically specific cases and the regularities of development through time. Only by enabling the assembling of a wide ranging body of information on the implications and the characteristics of the fundamental role the patterns of the built environment shaping each urban landscape play in the functioning and development of cities, can we learn about the mechanics of social resilience, the successes and failures, and approach alternatives and interventions in current practice with greater confidence. It is the task of this research to set that first step: to devise an appropriate means for the comparative social study of the basic material and spatial characteristics of urban built environments as they are inhabited across all urban traditions and throughout the full time depth of its existence.

The questions

From the above it becomes clear that I will work from a particular premise, i.e. urbanisation seen as part of the fundamentally human process of inhabiting the world, from which an endeavour will be launched to develop a methodology which is appropriate to a theory and conceptual framework empowering comparative social urban research with reference to its built environment. In doing so, this research will contribute to the realms of the man-environment paradigm and society-space relations at large. The main question this research will address is:

> How do we understand the role of the built environment as emergent from the process of inhabiting the world and the functioning of urban life and development, and how can we recognise and study this comparatively through time and across geographical areas, societies and/or cultures?

The consequence of this main question is that an appropriate object, field, and method of research need to be determined. The following questions break down the consecutive exploratory steps, each informing the next, comprised yet concealed in the main question above:

1. How can the urban built environment serve as an object for comparative social research and what level of social interpretation is comparatively viable? (**Chapter 1**)
2. How can it be ensured that the development of method is appropriate to the understanding of the research object ideationally and empirically, and how should a research process to this effect be structured? (**Chapter 2**)
3. What is an appropriate theoretical framework for understanding the role of the built environment in the human process of inhabiting the world? (**Chapter 3**)
4. Which information contained in the built environment is key to characterising and explicating its role in the human process of inhabiting the world and which meaningful constitutive element can be derived to operationalise in research? (**Chapters 3** and **4**)
5. How can the understanding of the constitutive element informing us of built environments’ role in human inhabitation, specifically in urban life and development, be conceptualised to fit the widest possible range of data on the urban built environment to suit a comparative frame of understanding? (**Chapter 5**)
6. How can such conceptualisations be operationalised in (empirical and technical) research practice on actual urban built environment datasets of different origins, covering both contrasts between urban planning traditions and a diachronic process of development? (**Chapters 6** and **7**)

7. Which are valid directions for analysis with comparative interpretive potential and how can such analyses be designed? (**Chapters 8** and **9**)

The thesis

The following section will briefly discuss and explain the order and structure in which the thesis is presented in the light of the questions formulated above. In order to determine how interpretive social research in comparative urbanism can be positioned, **Chapter 1** first provides a concise critical review of scholarly thought on the nature of cities. This indicates that a preoccupation with classification and the origin of cities has dominated discourse, but that such attempts to pinpoint the requirements of designating a settlement as a city result in static views and categories, preventing a critical assessment of how cities function comparatively as emergent from social processes. At the same time the physical form of cities is established as a historically widely available reference. Therefore a working definition of the city centred on urban life in an urbanised landscape is provided, which forms the background for this research. Secondly, **Chapter 1** determines at which level of detail interpretive efforts can be pitched to overcome the limitations of socio-culturally and historically contextual approaches, to make truly comparative contributions to the social knowledge of urban life and development. I decide that low-level interpretations on the recursive relationship between human beings and the material manifestations of their environment are appropriate.

Having established both an intellectual position and broadly the interpretive realm in which a comparative social research on urban built environments can take place, **Chapter 2** discusses how an appropriate philosophy of science can inform both the necessary foundational assumptions to inform conceptual theory building and the sequential design of the research processes through which ideational understanding and empirical data become structurally related. I identify that the critical realist strand of the philosophy of science offers cogent propositions to guide this research. While the tenets of a new critical realist adaptation in archaeological theory help redefine ‘the material’ as directly incorporating its human and social origin, both the archaeological and human geographical discourse on materiality seem unable to formulate research realising similar synergy. Nonetheless, human geographical adaptations of critical realism usefully distill both the research processes through which ‘the material’ could become part of social scientific research and help define the other necessary metaconcepts of ‘the social’ and ‘spatial (in)dependence’. On this basis subsequent purposive theorising and conceptualisation (**Chapters 3-5**) is ensured to enable comparative methodological development.

Chapter 3 presents a constitutive theoretical framework through which we gain a better understanding of the role of the built environment as emergent from the human process of inhabiting the world. A number of conditional statements are provided, first determining what it means to be a human inhabitant of the world, and second introducing series of abstractions framing the contingent consequences of inhabiting the world which are necessary conditions for the occurrence of the emergence of cities or, as we come to understand, inhabited urban built environments. **Chapter 3**'s bottom-up constitutive theoretical framework demonstrates that differentiation is key to the intelligibility of habitability of the social and spatial world and consequentially also the transformative making-habitable of the socio-spatial world, which captures the process through which eventually cities can be built. Boundaries are identified as the flexible notion denoting the recognition and introduction of differentiations as materialised physical properties constituting the subdivisions that compose the built environment complex. The affective and affording physical properties of materialised boundaries so assume their socio-spatial significance for urban inhabitation.

Understanding the inhabited built environment as a composite complex of boundaries allows us to take a new look at how spatial data truly represents the spatial and material characteristics comprised in urban built environments. Therefore, **Chapter 4** first critically selects the tenets of (social scientific and philosophical) boundary studies that can be related to how we understand the representative nature of spatial data. The determinant importance of the operation of seclusion for the spatial subdivisions of the built environment is discussed. Subsequently I introduce another sequence of abstractions designed to better appreciate how abstract spatial data refer to the concrete social empirical reality of the material presence of the built environment to its residing society as determined in **Chapter 3**. This leads to the introduction of the notion of types of boundary lines creating a built environment ontology of analytical units that is at once ideational and empirical.

Chapter 5, then, is pivotal for the methodological agenda of this research, as it presents the suggested ontology of Boundary Line Types (BLTs) with fully illustrated definitions.[1] **Chapter 5** first discusses the requirements of an ontology to ensure comparative applicability is maximised. Furthermore, it reviews the level of detail and

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[1] In the back of this thesis a supplementary table of abridged BLT definitions can be found, serving as a quick and easy reference throughout all chapters.

some material-spatial principles guiding how spatial data representing the built environment should be regarded to reveal the outline selection comprising the contiguous complex of subdivisions on the basis of which BLTs could be identified. After introducing the iteratively abstracted BLT definitions, I also reason through the consequence of investing spatial data with a formal redescription in BLTs. This produces the socio-spatial ontology intrinsic to a city or its socio-spatial signature of inhabitation. Finally three levels or contexts of socio-spatial significance applying to each BLT are identified, which both restrict and inform interpretive potential.

While at this point it would be possible to immediately proceed to a demonstration of how to put BLT identifications into practice, **Chapter 6** first offers a critical review of related methodologies studying the urban built environment. Although the theoretical framework and resultant conceptualisations form a completely new research context, making it a logical consequence that no appropriate method would preexist these efforts, the urban built environment has formed the object of research from other vantage points previously. Given the extent to which the primary data sources are shared, there is much to learn about the challenges and possibilities in data preparation and treatment from these other approaches. Therefore **Chapter 6** not only critically reviews why prevalent existing approaches, broadly divided over urban historical GIS (Geographical Information System), urban morphology and space syntax, are not suitable for the propositions in this research, but also how the methodological operationalisation of my propositions can benefit from their efforts. The practice of historically reconstructive mapping, the terminology of urban morphology, and the empirical analytical rigour of space syntax are especially of value.

Chapter 7 is dedicated to operationalising the BLTs by applying them to prepared spatial data based on the relevant material-spatial information contained in original representations of urban built environments in a GIS environment. To demonstrate the comparative ability of the aforementioned propositions, first two case studies are selected. Together these case studies should fulfill the requirements for a research process that can be effectively applied both across widely differing urban traditions and on the development of urban landscapes through time. This also implies covering a breadth of datasets of different origin: archaeological, historical, reconstructed, and contemporary. **Chapter 7** provides a rationale for selecting the cities of Chunchucmil (Classic Maya) and Winchester (western, British historical) as case studies to demonstrate the research processes. It further provides comprehensive technical detail on the varying processes of data preparation commensurate with the origin of each dataset, before discussing the practical assumptions (rules of thumb) necessary to carry out BLT mapping (identifications) beyond inevitable limitations to our knowledge about the datasets.

Chapter 8 serves a double purpose, first explaining the technical detail of the GIS data structure resulting from the practice of BLT mapping as presented in **Chapter 7**, as well as the limitations thereof in diachronic compilations. Secondly I hypothesise how this data structure within a GIS environment is supportive of interpretively meaningful quantitative analytical measures. To this end the second section of **Chapter 8** initially sets out in what light quantitative analytical measures can be understood interpretively and how their derivations guide explorations confined to the realms of the intrinsic interpretive value captured in the levels of socio-spatial significance (**Chapter 5**). Because the questions structuring this thesis do not foresee a full-fledged geocomputational effort to make such analytical opportunities operational, much of **Chapter 8** actually presents a rationale for directions of future research. In **Chapter 9**, in contrast, I present some preliminary analytical explorations and their interpretive potential as applied to two minor test cases selected from the BLT data on the case studies of Chunchucmil and Winchester. This chapter introduces a number of final innovations, including the initial geocomputational functionality that was sourced in support of this research. While these preliminary explorations and findings are necessarily very limited within the confines of this methodological research agenda, their tenets form a compellingly broad foundation enabling both visualisation techniques and analytical directions holding great promise for future research. Taken together this forms the basis upon which a body of comprehensive case studies could be built to gain a deeper understanding of the fundamentally human phenomenon of urbanisation and urban life.

The long term benefits of such profound understanding are wide ranging. Not only can research efforts be used as an underlayer for creating archaeological, cultural and historical knowledge about urban societal goings-on and explicate the developmental processes of (past) urbanisation, its conceptual and interpretive insights could eventually become reified in urban design and planning interventions. Employing this method may support or challenge the socio-spatial implications of hypotheses formulated on urban form in the past, present and future. Systematic comparative analysis and interpretation open our eyes to better appreciate the functioning and opportunities offered by inhabiting urban built environments which are alternative to our own contemporary experience.

CHAPTER 1 – STUDYING THE URBAN COMPARATIVELY

Introduction

The focus of this research is on a particular situation that may occur in the broad, long term process of human inhabitation of the world. When residence is taken up in a particular location and population rises, the landscape becomes increasingly manipulated through human interaction to accommodate the functioning of residency. Simply put, living in a landscape of our own making is what will be referred to as the 'inhabited built environment' (see **Chapter 3** for a theoretical treatise). In addition, the situation to which the scope of this research is limited is further specified as 'urban'. Urban is a problematic term, as it qualifies the life, activities and things to do with cities. Although cities and urban life have existed for millennia and currently over half the world's population is considered to reside in cities, there is no single agreed upon definition of the city. Disquietude over the lack of such definition has certainly not impeded cities as a substantive field of research, so much that arguably having a categorical definition of the city could be counterproductive for specific research in the first place (e.g. Smith 1989). Currently, the city or urbanism is a research theme in several disciplines and increasingly represented by the academic field of urban studies.

Taking the inhabited urban landscape as the result of an ongoing *essentially human process* and consequently a deeply historical phenomenon makes historical and archaeological thought on urban origins, as well as a social theoretical position towards urbanisation (or 'the urban') as a general process in human social life, of specific interest in this chapter. Before a scholarly contribution to the general study of 'inhabited urban built environments' can be made it is therefore necessary to contextualise, explicate and define the perspective on urbanism informing this research. Within this research's ultimate aims of developing a broad comparative conceptualisation and methodology, this chapter will first embed these efforts in contrast to approaches concerned with characterising the nature of urbanism and will offer a process-based working definition of the city centred on urban life. Subsequently this chapter will provide an explanatory background to understanding how studying the urban as a social process comparatively initially requires low-level (as opposed to highly contextual, see below) interpretive limitations and objectives, which is where the theoretical and methodological work in this thesis accomplishes its principal enabling contributions.

Urban studies

As the continuing rapid urbanisation of the world is widely recognised as one of the major humanitarian global challenges for the foreseeable future (Dittmar 2013) it is no surprise that urbanism should be at the forefront of research interests. Urban studies is not a traditional academic discipline and while various institutes with a focus on urban studies exist, as well as specialised research journals, its core area of interest is still fragmented over many different academic disciplines. Nonetheless, Bowen et al. (2010) have demonstrated that there is considerable coherence amongst the intellectual pursuits associated with urban studies. Importantly for this research, however, Harris & Smith (2011) rightfully point out that Bowen et al.'s (2010) analysis of the research field overlooked the significant presence of and contributions made to urban research from historical vantage points.

When talking about the long term process of human settling as part of inhabiting the world, this current research deliberately intends to include all of human history: from prehistory to the present. If a contribution is to be made to improve the understanding of the conditions and characteristics of urban life caused by a settling process that keeps on increasing the world's urbanised population, it is paramount to take a fundamentally human perspective that in principle is able to facilitate comparative and diachronic understandings across all instances of such residency patterns. Since it would be impossible to develop a satisfying cross-section of representative examples of all instances of urban life, both longitudinally and across culture areas, investigation becomes centred on the way in which, I expect, research efforts at large could build a body of work on cities based on commensurable foundations.

Naturally the first consideration is the availability of equivalent information on urban places across time and space. As any archaeologist would be quick to point out, the material record upon which their discipline is based is probably the best preserved information source on the deep past of human life. Furthermore, no anthropologist would deny that material culture is part and parcel of continuing human life, society, and culture (see Miller 1998, 2005). This is easily extended to include the presence of the material composition of urbanised inhabited landscapes. “The tangibility, ubiquity and persistence of physical form make it the most suited to act as the point of reference for co-ordinating and comparing aspects.” (Kropf 2009: 117) The same is recognised by Harris & Smith (2011: 103), who note:

> “[…] arguably the most enduring characteristic of cities, one that almost invariably forms the basis of their definition, concerns their physical presence. They are dense, well-populated settlements with considerable investment in the built environment, and other infrastructural components. We can, and do, debate exactly how large, or how dense, a place has to be to count as urban, but hardly anyone doubts that size matters.”

Parr’s (2007) recent ‘spatial definitions’ of the city also all initially refer to the developed area, the physical entity, before moving on to characterise three kinds of socio-functional city. So it makes a reasonable expectation that if we are to embark on the development of methodology for the social study of the full range of urban possibilities throughout human history, our first point of call would be the physical way in which the transformation of the landscape accommodates this intense and relatively large scale inhabitation, even though not all such modifications could possibly be retrieved.

The notion of comparative urbanism exists in urban studies or urban geography, but Smith (2009b) draws attention to the fact that considering the breadth and depth of urban traditions, comparative urban geography displays a severely limited historical scope (a recent exception is Briggs 2004). Though interests in the physical and architectural characteristics of the built environment from a social and spatial point of view often display a historical interest (e.g. Bastian 1980; Daunton 1983; Lawrence 1996; Rotenberg 1996; Jenkins 2002), research very rarely penetrates deeper than about two centuries’ worth (Kostof’s (1991, 1992) well-known historically descriptive classifications of urban form are an exception). This apparent historical myopia is noted for both urban and planning interests in human geography (Nijman 2007; Smith 2009b; Harris & Smith 2011; York et al. 2011) as well as historical geography in particular, often precluding history beyond the early modern period as an earliest starting point (Jones 2004; Lilley 2011b). The particular field of urban historical geography (see Dennis & Prince 1988; Denecke 1988, for a respective discussion of British and German research practice), which has allegiances with urban morphology (see Conzen 1960; Moudon 1997), did cautiously venture into the early medieval period (e.g.

Denecke & Shaw 1988), but this has not resulted in a more structural presence of historical depth. Nonetheless, there is no clear reason why this preoccupation with recentism should prevail. On the contrary, from the perspective of human or society-space relations and the ongoing processes of urbanisation, there is potentially much to gain by structurally engaging the building processes composing the urban *longue durée*.

Not only is there a temporal myopia; urban research has culturally favoured western and globalised examples of urban form (Wheatley 1969; Graham 1996; see Edensor & Jayne 2012 for a recent attempt to intervene). The urban alternatives (cf. Smith 2012) that different areas of the world with their own environmental and cultural evolution have known before industrialisation and globalisation have been neglected or brushed aside with all ancient (pre-industrial) urban traditions in several seminal texts on urbanism (e.g. Mumford 1961; Sjoberg 1960; Fox 1977; see Graham 1996)[2]. This cultural preoccupation could in part be explained by the desire to formulate successful planning policies, acting as a driver for inquiry in practice. As Habraken (2000: 10) bravely states:

> "[t]he necessity of a disciplined and detached stance, so self-evident in the natural sciences, is by no means self-evident in studies of the built environment. We are fully immersed in the object of our inquiry — in fact, we are part of it — and value judgments color our every observation."

So, it is argued that even planning professionals would have much to gain from trading judgemental and normative assertions for analytical insights. Although I will not join Habraken in his recommendation for a natural scientific perspective, an appeal is made to supersede western cultural embedding of urban scholarship in favour of approaching urbanism as an essentially human and social phenomenon, forming part of geographically and culturally separated traditions. Only in so doing could our eyes be opened to the lessons concealed in the alternative solutions emanating from the common developmental processes of settling and cohabitation humanity has lived through. While I agree with Fletcher (2010: 253) that to suppose the world's wildly varying urban traditions "had equivalent socialities would strain the contextual uniqueness of human social life", to launch research from specific culture historical

[2] Rather worryingly some of this myopia persists even to the present. In Clark's (2013) *Oxford Handbook of Cities in World History* the presence of Pre-Colombian cities is severely marginalised and in so doing misrepresented.

contexts (i.e. the ideographic tradition in human geography) would grind insights to a halt in isolated particularities (contextual interpretation will be discussed below). A fuller appreciation of ancient urban traditions as examples of the same social processes as current urbanisation holds great potential for increasing our understanding of urban challenges today (see Smith 2010a, 2012).

It has since long been recognised (Pollard 1977: 46) that “[a]rchaeologists, in particular, have much to offer to increase our understanding of the structure and functioning of urban settlements.” Yet, data constraints and particular disciplinary foci have made efforts to structurally address this potential scarce. More recently, however, it could be argued that technological advancements and accumulated archaeological research have made it much more feasible to undertake comparative research on the deeper history of urbanism (Smith 2012). Nonetheless, it should be acknowledged that archaeology lacks the rigorous frames of reference and critical analytical measures with which such endeavours could be contrived (Smith 2012; Smith & Peregrine 2012). Archaeological efforts to date have concentrated on the issue at a different scale, undoubtedly in part due to the overwhelming influence of Childe’s (1950) pivotal proposal of the ‘Urban Revolution’[3] (Smith 2009a) and in part by the fragmentary and limited nature of archaeological data.

Urban origins

The debate on the origin of cities is closely tied to defining the city as a category and classifying different kinds of cities (e.g. Wirth 1938; Fox 1977). Even though this research is little to do with demarcating the principal nature of the city, accepting the urban as an extant mundane situation, much foundational and deep historical urban thought has sprang from these concerns. In order to explain the principles of a low-level interpretive comparative urbanism based on a process oriented working definition of the city, one should be aware of the wider context in which cities emerge as both a phenomenon and a research concept.

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[3] Smith (2009a) discusses how Childe’s first presentation of this term appeared in his 1936 book *Man Makes Himself*, but how his more accessible paper from 1950, The Urban Revolution, went on to become one of the most widely cited papers published by an archaeologist. The latter is generally recognised as the full-fledged discussion of his ideas on urbanism, though these should be seen as part of a wider appreciation of the emergence of complex societies characterised by many traits which are also of importance as urban features.

Childe's contribution to urban research was part of a much larger body of thought, which included an economic critique and reimagining of the prehistoric three-age system and an influential position on the culture-historical approach as applied to material culture. He presented his arguments to a broad public. His socio-economic evolutionary concepts went on to find wide appeal and form a major influence across historical disciplines into the 1990s (Greene 1999). He coined the term the Urban Revolution (amongst others, such as the Neolithic Revolution, inspired by the quick changes of the modern Industrial Revolution) to mark the process of transformation from primarily agricultural societies into more complex, state-based, urban societies. Adam T. Smith (2003) emphasises that Childe was actually more directly concerned with state formation (cf. Smith 2009a on complex societies) than with urbanism as a concurring phenomenon, in spite of the ordinary archaeological reading of his work emphasising the emergence and traits of urbanism. In addition, Wheatley (1972: 612) points out that Childe (1950) actually isolated just one primary dependent variable in the generation of urbanism: "the progress of technology, resulting in the augmentation of food surpluses[.]" Consequently, according to Wheatley, Childe succeeded in demarcating a stage of development rather than establishing the process of the Urban Revolution.

Childe's persuasive fascination with the origin of urbanism is logically better served by an inter-city than an intra-city scale. In addition, the coarser nature of evidence required for discussing urban systems and settlement patterns relieves some of the pressure on archaeological resources for more intensive mapping and excavation. Coincidentally crude data is an adequate fit for purely quantitative empirical spatial analyses, whilst still relevant for addressing questions on why cities appear at certain locations and in specific relation to each other.

The relative placement and assessment of the importance of sites within settlement patterns have often been tackled by applying size-rankings and spatial pattern analyses (e.g. Kowalewski 1990, 2003; Falconer & Savage 1995; Savage 1997; Drennan & Peterson 2004; Algaze 2005; Smith 2005). Christaller's (1933) economic 'central place theory' has been influential in the development of such supra-city quantitative analyses in archaeology. Wheatley (1972) gives an anthological overview of research in central place theory when it was still very much in development. Tenets for current research on multiple nuclei cities and the internal structure of metropolitan regions followed from this theory. The influence of central place theory in archaeology can currently be recognised in predictive modelling for settlement patterns (Vaughn & Crawford 2009;

Fletcher 2008), which bears relations to rank-size rule methods. Increasingly in both history and archaeology regional and global references to urban systems are advanced by network approaches (e.g. Verbruggen 2007; Brughmans et al. 2012). In contrast, Smith (2006) presents a concise overview of a selection of more interpretive concepts and models which combine types of cities with several ways, including those artificial, of founding cities.

Quantitative approaches alone cannot appreciate the complexity of urban origins, evidence of which actually is indicative of much more diversity and plurality in the processes of urban emergence than Childe's historically influential 'revolution vocabulary' (Greene 1999) suggests (Blanton 1982). Criteria for the definition and classification of urban settlement are problematic and, except for certain statistical studies, not necessarily informative (cf. Grove 1972; Smith 1972). At the same time, a rank-size based approach has indicated that the view of Mesopotamian urbanism as respecting similar principles as dense western urban conventions might be in need of revision to accommodate the sheer variety of urban settlements (see Falconer & Savage 1995). Classificatory and quantitative approaches thus can aid the formulation of further questions and research.

Distinguishing city types and providing classifications results directly from the attempts to identify or disentangle the variables and characteristics that constitute a city. Indeed the definition of what a city constitutes has been a matter of debate for the better part of a century. One of the pivotal contributions to this debate came from Louis Wirth (1938). He was the first to make apparent the lack of a sociological definition of a city. Introducing a sociological definition of the city would immediately take into account that urbanism is not confined to the city locus. He envisioned a definition relying on four characteristics: population size, density, heterogeneous individuals, and settlement permanence, which are still of relevance in much contemporary thought on this subject.

Categorical cities

Paul Wheatley (1972) categorised Wirth's (1938) take on urbanism as a trait-complex approach, "converting a simple aggregate of features into an ideal type construct." (Wheatley 1972: 608) He presents the reader with an overview of the types of strategies recognised within the elusive term 'urbanism' in fashion at the time. Trait-complex approaches exist next to: ideal-type constructs, which dichotomise urban society to non-urban counterparts such as the urban-rural divide; ecological theories of urban development, which posit urban society and social organisation as responses to pressures of the environment, including measures of biological determinism and the origins of urbanism; cities as centres of dominance, which view the role of the city as a power phenomenon, leading from the city as generator of effective space to Christaller's economical central place theory, producing hierarchies within city regions; and expediential approaches, relying on definitions based on numerical size for classification. Wheatley (1972: 621-622) concludes that these types of strategy are not mutually exclusive:

> "[A]lthough the *strategies* are complementary [...] they are jointly directed towards four seemingly contradictory *conceptions* of urbanism in terms of (i) an interactional model which emphasizes the growth and structure of specialized networks of social, economic, and political relationships focused in cities; (ii) a normative model in which urbanism is viewed as a way of life. [...]; (iii) an economic model, concerned primarily with productive activities in a spatial context; and (iv) a demographic model, which treats urban forms essentially as aggregations of population in restricted areas."

Classification is relevant because effectively it would be impossible to pinpoint the emergence of cities if it cannot be defined what a city is. This problem permeates the continuing discussions on the origins of urbanism. Outside archaeology Jacobs (1969) is often credited as the one to adopt the case of Çatalhöyük (southern Anatolia, Turkey) as the earliest city in the grand narratives devised to explain the emergence of urbanism. Although archaeologists cannot quite agree on whether Çatalhöyük can qualify as a city, town or village (Taylor 2012), simply on the basis of size, Fletcher (2010) sees reason enough to dismiss its potentially urban status. Emberling (2003) denies Çatalhöyük this status on the basis of a missing hinterland. Taylor (2012) adapts the disagreement in archaeology in his revamped progressive model of urbanism where the city comes first. So Çatalhöyük becomes reputed for showing the first features, but not all traits of 'city-ness'. As opposed to this functional placement Soja (2010; also Blake 2002) still uses Çatalhöyük as an urban case study for supporting certain arguments around the progress and acceleration of innovation as part of the urban origin narrative. Importantly, although the authors mentioned here to differing degrees acknowledge alternative urban traditions, this grand narrative approach seems counterproductive with regards to understanding the common formative processes of urbanisation. Meanwhile archaeologists seem to have become more pragmatic. From an infatuation with ideal type categorical typologies of differing cities (see Fox 1977; e.g. Sanders & Webster 1988), Cowgill (2004) suggests replacing typologies with more flexible variables placed along axes or dimensions. Smith (2007, 2010a, 2010b), in turn, privileges a functional definition of the city (as in fulfilling urban functions), which then can be employed usefully in framing the case studies of others (e.g. Fernández-Götz & Krausse 2013). For contemporary cities Parr's (2007) interrelated 'spatial definitions' display a similar concern with the social functions of the city as a physical entity (the built city), bringing consumptions of goods and service provision in connection with employment opportunities and requirements.

This is important as concerns with defining urbanism and classifying places as cities have not only been problematic with regards to the earliest known cities. The overall futility of a single grand narrative is also exemplified by the debate on Maya urbanism. When Sanders & Webster (1988) cast doubt over the urban status of Maya cities — an opinion voiced earlier by Coe (1961) — they were criticised by Smith (1989) and Chase et al. (1990) for overgeneralising Mesoamerican urbanism as a whole and failing to recognise the variability and complexity of urban functions and possibilities. Smith (1989; also McCafferty & Peuramaki-Brown 2007) points out that archaeological data in the region is too scant to make such all-encompassing statements, while with regards to Aztec settlements archaeological evidence becomes generally more productive when viewed as part of an urban tradition (see also M.E. Smith 2008).

Depending on the criteria one uses, Maya cities could be classified as urban, which is the way they were approached by many before anyway (Andrews 1975). Fortunately Mayanists have since moved on, retaining the urban vocabulary (Grube 2000; Sharer & Traxler 2005; Joyce 2009) and leaving the debate behind. In the light of the recent discoveries of urbanised sprawl for a multitude of Maya cities (e.g. Chase et al. 2011), this corrective seems fully justified. It was conceded that such discussion is not necessarily helpful in the understanding of the nature of urbanism and how it functions as part of a societal structure, regardless of how state-like or urban that is (Graham 1999; McCafferty & Peuramaki-Brown 2007). Acknowledging the urbanised nature of such settlements, the notion of 'tropical urbanism' has been suggested (Graham 1996, 1999). Alternatively the Maya tradition has been categorised as featuring a 'low-density (agrarian)' pattern of urbanism (Fletcher 2009, 2010, 2012), which also applies to the ancient Khmer of Angkor Wat, whose culture Coe (1961) equally asserted to not feature cities. Arguably similar traditions existed in e.g. 18-19th century Africa (Smith 2011a; also Storey 2006), but it is not a current urban settlement pattern. This does not withstand that these thriving urban traditions were remarkably resilient (Fletcher 2010; Isendahl & Smith 2013). Unfortunately without an equivalent in today's western and globalised views on urbanism these traditions have yet to receive the scholarly scrutiny they deserve for the benefit of facing the global challenges associated with urbanisation. Meanwhile the extant categories used to characterise urbanism can only be flexibly applied (M.L. Smith 2003a; Cowgill 2004) and even then the "problem is that these categories are […] insufficient, cross-culturally problematic, and too protean. Something more rigorous is needed to adequately define urbanism and incorporate low-density urbanism both in the industrial and in the agrarian worlds." (Fletcher 2010: 252)

It is clear a resolution is not yet reached as the debate on early urbanism and formulating a comparatively appropriate definition of the city persists. Interestingly, most considerations still roughly follow Childe's broader arguments regarding evolution of production, social complexity, and population growth, which tend not to be separated from lateral discussions on state formation. The cultural myopia on western urbanism, often uncritically placed in direct historical relation with antiquity and Mesopotamia (see Wheatley 1969; Graham 1996), has tainted the discussion on defining the city and made it difficult to study alternative urban traditions as part of a common human phenomenon. The unresolved discussion — revisited by Smith (M.L. 2003a) and Fletcher (2010) — demonstrates that when going beyond historically and contextually specific documented decrees determining city status and inhabitants' civic rights administratively, the picture of what constitutes a city remains muddled. Following Fletcher (2010: 253): "The study of urbanism currently does not have an agreed basis for rigorous worldwide comparison." All this suggests that when laying the foundation for comparative studies no single (static) definition would result in an appropriately equal basis for selecting and studying cases. In contrast, the suggestion for a focus on *how cities function as a process* is something to subscribe to when a deeper understanding of urban life and development as part of the inhabitation of landscape is sought.

Comparative urbanism

Fortunately, as in urban studies discussed above, archaeological research has not been deterred by the disagreement over definitions. Each project either explicitly or implicitly chooses its own perspective, although generating broader understandings is hampered by the lack of appropriate and rigorous frames of reference (Yoffee 2009;

Fletcher 2010; Smith 2012). Nevertheless, ancient cities and urbanism have received a lot of attention in archaeology during the past decade or so. A representative selection of archaeological work on cities can be found in no less than five recent volumes: Smith's (M.L. 2003b) *The Social Construction of Ancient Cities*; Gates' (2011) *Ancient Cities*; Atkin & Rykwert's (2005) *Structure and Meaning in Human Settlements*; Storey's (2006) *Urbanism in the Pre-Industrial World*; Marcus & Sabloff's (2008) *The Ancient City*. As Yoffee (2009) notes, several of these volumes do not go through the effort of critical synthesis nor do they all constructively live up to their intellectual foci. "[T]he cities portrayed in these volumes for the most part seem abstractions, lifeless, and unconcerned with the lived experience of citizens." (Yoffee 2009: 282) This is a surprising remark, as despite the initial decontextualisation of a comparative approach emplaced lived experience (see **Chapter 3**) will be part of a low-level interpretive approach as discussed below. Furthermore, these works actually inadvertently help to dichotomise the field of comparative urban studies by juxtaposing the ancient or pre-industrial city with contemporary urbanism.

Despite Smith (M.L. 2003a) acknowledging the important similarities across urban spaces regardless of their era this insight does not become a structural part of the contributions in her volume. Yoffee (2009: 282) remarks "any comparison of early cities with modern ones needs to be taken seriously. We can learn from our colleagues in historical archaeology […] and in urban geography." Even though he upholds the view that ancient cities are predominantly not like modern cities he reasons "comparison will lead us to explain why this is the case." Vice versa, Smith (2012; also Smith 2010a) cogently argues why and how studies of ancient urbanism could be of relevance to urban studies today (see also Smith et al. 2012, on archaeology's contribution to social science debates). So, what is considered to be a city today can serve as a basis for ancient-modern comparisons without assuming their differences and similarities or questioning and defining the exact nature of urbanism.

The origins and nature of urbanism, then, remain a particularly framed pursuit, which may obstruct and restrict comparative investigation into the processes within which cities emerge. The concern in this research is certainly not to present yet another version of a grand narrative explaining the urban phenomenon in general. Paul Wheatley (1972: 602) already asserted that "it is not particularly profitable for a social scientist to attempt to discuss the nature, the essential quality, of urbanism. That is a metaphysical question more amenable to philosophical enquiry than to the empirical methods of the social sciences." Here, the concern with cities lies rather with the acceptance that cities exist in necessary relation to the general processes of human settling and landscape modification, and to see these places as lived-in and being further developed in that process. I will not distinguish between different types of cities, nor between ancient (pre-industrial) and modern cities. Instead I aim to develop an approach for the social study of urban landscapes anywhere at any time.

Yet, to contextualise this research, it cannot be denied that some clarity is desirable on how the quality of urbanity of a place is regarded. From the above it is clear that in order to achieve a methodological contribution, a rigorous basic conceptualisation should be at its basis and the definition of its urban context should allow for all imaginable pluriformity. To provide such clarity and an interpretive frame of reference a concise working definition (cf. Smith 2007) based on the process of settled life will be presented here. For the test cases, later exemplified (**Chapter 7**) to operationalise the methodology this research develops, it is assumed rather than tested that this definition applies.

Social practice based definition of cities

My working definition of urban life, which includes the prerequisite mundane existence of cities, is as follows. A city is a contiguous locus positioned in the physical landscape, which has been developed for human inhabitation through social interaction and is resided in to such extent that for a predominant number of the population there is no unavoidable need to leave its confines, because all of everyday life's necessities can be met through social relations, either directly or indirectly (i.e. using relations to agents and (resource) locations external to the contiguous locus' confines), which can be found within its confines. The interactions of everyday life, in turn, are constitutive of, accommodated and mediated by, an environment which has become physically so developed as to permit predominantly permanent dedicated occupation by such social processes, which in themselves are also constant negotiations with their social and physical environment.

There are a few things to note with regards to this process oriented definition[4]. First, it does not speak of any specific traits. That is, it does not prescribe what is entailed by the necessities of everyday life, though it can be conceded that for relative

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[4] Ley (2010) presents a preliminary attempt on a phenomenological systemic basis for a morphological definition of the city, while the definition here leans on the process of inhabitation of which built form is an outcome (see Chapter 3 for the theory, and Chapter 6 for urban morphology).

permanence this must be delimited on the lower end by the requirements for survival. Second, it does not prescribe which aspects of the urban landscape qualify as contiguity as this is dependent on the processes of everyday life, though it does require the features of the developed landscape to serve (unspecified) purposes within everyday life. Third, it makes no claims towards thresholds of size and density, as this is dependent on the population and the way they have developed the landscape for inhabitation. Fourth, it does not make inhabitants 'urban prisoners', i.e. they may not have to leave to up-hold their everyday functioning, but still can do so for other reasons. Vice versa, non-residents can enter and partake in the city. In this way its structural yet autonomous placement within the wider landscape and external relations is ensured. In addition, the predominant proportion of the residents cannot be fully reliant on external relations controlling subsistence as in literal prison complexes. Fifth, the difference between urban-rural is a transitional and flexible distinction. It could be expected that beyond the city's confines people increasingly lead an everyday life in which they are not reliant on the providing relations within the city's contiguously developed locus. At the same time, this leaves open the possibility that the existence of cities to a large extent has 'urbanised' the whole landscape (see Blake 2002). Sixth, the definition does suppose a measure of social complexity, which should be sufficient to allow everyday life for individuals to unfold within the locus' confines through using all relations and interactions (including some that may be external) that take place there. Seventh, it requires a view of cities as always contingent on the processes of inhabitation and development taking place. This means that a distinction should be made between studying cities as social phenomena and a purely empirical view of the physical characteristics cities display. Archaeologists typically encounter cities as abandoned, derelict and disturbed developed loci. Empirical recording alone cannot *comprehend* the constituents of the city. Studying cities socially should entail studying urban life, and therefore assume all urban built environments as inhabited environments.

Eighth, and related, this definition renders certain intensively physically developed loci non-urban when it cannot be established that everyday life could unfold within the city's confines. This may include excesses of monumentality and (political or cosmological) planned idealism, which may display physical characteristics almost impossible to distinguish from the complex composite of places with 'true urban life'. Indeed, the physically developed environment may hold the potential to accommodate such life even though it has not taken place.[5] Although elaborate religious and palatial complexes may have relied for their subsistence on a hinterland, developed contiguously only to a certain extent, these are examples of monumentality rather than full-fledged cities.

Finally, however, the main admonition of this definition, and the restriction to its effective application to any place, is the probable impossibility to affirm the knowledge that any developed landscape fulfilled the requirements for everyday life to take place within its confines. Furthermore, it should be admitted that many places currently not commonly regarded as urban would fulfil these requirements. Contemporary multinuclear city-regions might hypothetically fulfil the requirements as both separate cities and as a single one. Consequently, but productively, this definition provides grounds for studying elaborate places of settlement in their own right and on the basis of their intrinsic characteristics, but it leaves open the question of which exact traits make cities unique from settlements which are not cities and how these might differ from society to society. It therefore becomes contingent upon the comparative framing of research from this process oriented perspective if such questions can be answered in the future.

It is my premise that sociality is at work in all humanly constructed spatial contexts of cohabitation, and therefore whatever information we use to study urbanism requires a social theoretical understanding. The definition above follows and further qualifies the lines of a particular 'social practice' based reading of urbanism elucidated by Joyce (2009: 192):

> "[S]ocial and political formations like ancient cities and polities are instantiations of ongoing social relations simultaneously embedded in and both producing and reproducing historical traditions [...]. Rather than integrated and coherent, societies are fragmented and contested to varying degrees such that there is never complete closure to any system of social relations. Practices and the cultural and material conditions that constitute landscapes are always negotiations among differently positioned actors — socially embedded individuals and groups — distinguished by varying identities, interests, emotions, knowledge, outlooks, and dispositions. As locations characterized by a "greater concentration of social relationships" (Southall 1983: 10), cities are places where these negotiations are perhaps most concentrated, intense, and unrelenting."

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[5] China is reported to have planned and built huge urban areas that nonetheless, to date, have never been occupied, while they hold the potential to fully accommodate the processes of urban life.

In this way Joyce permits a research perspective on urbanism that is close to Graham's (1999) suggestion that it is more productive to shift interests from what a city is to how a city works.

A deeper theoretical provenance of my working definition lies with Pred's (1984, 1986) conceptualisation of place as a historically contingent process. "Places are a kind of micro-geographies, in which many individual territories interact and biographies collide. The crossings of behaviour and movement generate spatial transformations and localise structures. The historical construction of place involves the appropriation and transformation of space as well as the reproduction and transformation of society in time and space." (Vis 2009: 75) In spatial terms this renders the city merely an intensively developed place, which conditions the everyday life simultaneously responsible for its formation. A contextualisation based on process opens the way to understanding the dynamics and functioning of places, upon which many of the static categories necessary to classify a variety of city types are contingent.

Ancient to modern comparisons are most useful for how they can elucidate the ways in which places functioned and have been developed as constitutive effects of social life. Cities and their structures are emergent from the interactions of locally residing urban life. This social practice based view can exist next to the other explanations of urban existence. Following Joyce (2009) these include: 1) cultural evolution: based on a model of linear progression typically assuming a relation to complex social organisation; 2) functional: including the many city types following from a main functional characterisation, e.g. political, religious, regal-ritual, administrative, and mercantile (see Fox 1977), but also the city-state (e.g. Hansen 2000) as opposed to cities in territorial states (Trigger 2003); 3) elitist: an authoritative power drives the settlement, e.g. the concepts of synoikism (see Blake 2002) (also known as synoecism or sinecism), where an authority may force relocation so an amalgamation of residence develops as a single urban unit (for an example see Bakirtzis 2003); 4) action theoretical[6]: a catalytic and/or innovation based explanation; 5) environmental: emergence of settlements based on natural factors and resilience (see Trigger 1972). Seeing urbanism as social practice actually necessarily underlies all of these alternative perspectives without predetermining any of these as the main driving factor for city

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[6] This should not be confused with Weber's social action (Campbell 1981), Von Mises' (1998) purposeful action, Giddens' (1984) purposive action or agency, and De Certeau's (1988) resistance within everyday life, all of which qualify (inter)action generally.

foundation or its particular development. In the end all urban landscapes are caused by a common societal process[7].

What to study comparatively

This chapter was started with the notion of the 'inhabited urban built environment', for which the urban context is now explained. However, it also incorporates the logical object of study or information source for a broadly comparative methodology in urban studies due to its physical endurance and ubiquity (Harris & Smith 2011). Although recent years have seen some particular attention to comparative urbanism in contemporary urban studies (Robinson 2004; Dear 2005; Nijman 2007; Ward 2010) it is important to note that urban geography (as urban sociology in general) under influence of Lefebvrian (1991) propositions for viewing space as socially produced and imagined, has become more concerned with society as taking place in the context of the city than the life of the city itself (Zimmermann 2012). Ward (2010) shows that comparative urbanism has been around in various guises, notably with quantitative beginnings using the city as a pre-given bounded locality, for several decades, but recently has shifted towards the fashionable socially produced and relational strands of social theoretical thought. In so doing, cities are not themselves the object of study, as the focus has become fixed onto the socio-culturally contextualised activities that take place within it, which are part of much more fluid and transient far-reaching social structures. This still implies that contemporary comparative urbanism will not necessarily elucidate how cities as particular places in their own right function (cf. Yoffee's (2009) remark on the lack of lived experience cited above). For example in Robinson's (2004) work cities become cogwheels in a global postcolonial narrative (see Clarke 2012), while in Dear's (2005) work urban life and city-regions receive their meaning from specific socio-political and cultural contexts. The low-level interpretive approach that will be developed in the remainder of this chapter makes use of empirical information on each (physical) city itself, whilst the social implications of this remain decontextualised from segregating particularities to empower comparative understanding.

Recently, especially German urban sociologists have proposed to refocus research on the city itself, without letting it become immediately subsumed by cultural contexts as is the case in current social research on cities (see Löw 2013). Their approach is

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[7] Chapter 3 presents a conceptualisation of the causal processes in human and social life leading to the generic construction of inhabited (urban) built environments.

based on what they call the *Eigenlogik* (intrinsic logic) of cities (Zimmermann 2012; Löw 2013) and seeks to redress social urban research to regard the city-specific characteristics. It propagates, in tandem with architectural sociology or anthropology (Delitz unpublished), the pursuit of a sociology *of* the city rather than a sociology *in* the city (Zimmermann 2012; also: Löw 2008). Architectural anthropologist Yaneva (2012: 4) states:

> "The danger is that when we talk about *different* cities (Cardiff, Sydney, Paris, London), *different* social contexts and *different* urban cultures, we tend to describe local treatments of the universal. Too often we assume that cities have common features such as infrastructure, markets, transport networks and city authorities. Culture is taken as a variable that is relative and situated."

Whereas early adoptions of the *Eigenlogik* perspective (Löw 2013) seem to focus on a city-specific cultural history with a minor role for the particular material properties of spaces that compose the place, architectural anthropology repositions that interest.

Delitz (unpublished) proposes a scheme of major architectural properties to broadly characterise cities by. Material properties or the actual substance of cities are part of the *Eigenlogik* of cities. However, relational, imagined, and contextual approaches to urban research tend to overlook this substance as a ubiquitously present, yet uniquely formed, object of study. Griffiths (2013) notes that the same is happening in the humanities following the spatial turn in history (e.g. Arnade et al. 2002) as influenced by the same socially constructivist thought (e.g. Briggs 2004, places cities as part of historically specific larger designs for society). Yet, an approach to cities as social practice in space, or society-space relations (Griffiths 2013), and emplaced inhabitation (cf. Ingold 2008a; Howes 2005a, see **Chapter 3**) has much to gain from direct engagement with what places were physically really like for the inhabitants. So the complex composite of the physical shapes of the urban built environment embodies a cogent comparative source of information into the functioning of particular cities as practice is an inherent part of its presence and significance.

This positions research on an intra-city, individual inhabitant, scale, requiring quite intricate details on the way space has been built up. While relatively easily achieved for contemporary cities, further back in time and archaeologically it is a challenge to retrieve a similar level of data. Where urban historical research can often roughly distinguish which sectors of a city were developed when, other evidence is typically scant and piecemeal. This results in area or zonal maps, the resolution of which is too coarse to enable discussions on the experience of the inhabitants (e.g. Historic Towns Atlas series (Lobel 1969; Speet 1982); Conzen 1960). Increasingly, there are also mathematical and agent based approaches that seek to express the evolution of the intrinsic shape of cities in law-like formulas (e.g. Batty & Longley 1994; Bettencourt 2013; Longley & Batty 2003; see Sayer 1979 for a modelling critique), which are argued to incorporate social factors in formalisations. Though such methods may steer investigations and inform planning through isolating abstracted factors in city development comparatively, they are a long way from comprehensively addressing human and social experience of inhabitation and understanding the opportunities for interaction and development.

The open-endedness and complexity of real social systems and processes, as emphasised in complexity theory (Bentley & Maschner 2003, 2009a), suggests that such models and formulas will never be able to fully account for how processes take place in the real world, despite critical applications of modelling making interesting specialist research tools. At the same time, it should be acknowledged that actual understanding in social science is subjectively limited to one's own frame of reference. Inter-subjective understanding even restricts direct linguistic communication (vs. Zierhofer 2002; cf. Vis 2009). Learning processes and emplaced experience, such as geographically delimited inhabitation and acculturation, may lead to biography convergences which enable improvements in inter-subjective understandings. Nonetheless, uniquely positioned and situated individuals (cf. Hägerstrand 1975, 1976; Pred 1977, 1981; Thrift & Pred 1981; Vis 2010) cannot achieve an equalising level plane of immediate exchange.

The same rational actions[8] and the same language are likely to mean slightly different things and be intended slightly differently. "[…] it cannot […] be safely assumed that the words a community uses to refer to the actions are a sufficient description of what is happening, or why. Nor can we assume that the social actions that are concurrent with a material assemblage are necessarily compatible with it." (Fletcher 2004: 111) In the same way the understanding, interpretation, and appreciation of outcomes and intentional messages will inherently differ between individuals, even if they can be said to generally or predominantly adhere to an overarching scheme. This intrinsic individualism alone gives social processes openness and therefore the

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[8] Rational actors should not be confused with conforming to normative rules. Decisions to act are ordinally reached (see Von Mises 1998; Vis 2010), one prefers to do something rather than something else with the expectation that it will improve one's position and situation. It is not prescribed that any action will have the intended effect nor can it be generally prescribed what is considered to be an improvement. Rational actions are subjective and may therefore seem irrational to other individuals.

flexibility to *change* at the hand of individual (inter)actions with the social and physical environment. Moreover it stringently confines the potential for comprehensive explanation to historically and culturally specified contexts.

Even with detailed knowledge of the context applies that "[…] similarities between individual plans, building forms and decorative elements do not necessarily imply that they have the same meaning. As we now know, comparable shapes and plans can easily be considered representations of different realities." (Mekking 2009: 35) Given this individuality and arbitrariness of the 'meaning' of intentional acts and communication, be that cultural, ideological, cosmological, religious, political or other, it is surprising that the shape of the built environment and architectural styles and traits have readily sparked research and interpretation on exactly that level.

Even when this kind of meaning and intention underlie the decision to build up space in a particular way it does not withstand that the primary effects of its physical occurrence take place on a more fundamental level of experience and potentiality rather than its presumed meaning. With regards to style, architect and Mayanist Andrews (1975: 32) asserted:

> "[...] it can be argued that style is a secondary indicator of cultural tradition, since the larger Maya area appears to be fairly homogeneous when more basic factors are considered. Style as such has very little to do with determining the physical organization and spatial order of the centre as a whole and can be thought of as a superficial overlay which is subject to change at will [...]."

Rather than first considering the basic (common) causal effects of the space having been built up and structured into a particular complex — which has immediate implications for restricting and enabling opportunities of encounters, interactions, and framing the outcomes of interactions — archaeologists and anthropologists tend to be seduced by their ability to order and organise according to (visual) traits and patterns and interpret aided by coarse analogies with other data on particular (instead of comparative) high interpretive levels.

Representation and meaning

Representational thinking for interpretation as relevant to specific contexts is both favoured and well-explained by Mekking (2009: 25).

> "Transversal thinking always and everywhere enables anybody to relate people, events and other aspects of life, irrespective of their being causally related or not. [...] Because building is an identifying act of positioning oneself in public space, the mental horizon of the patron-builder will inevitably be part of a worldview, a religion, a political ideology, or even the marketing strategy of a multinational. [...] If we focus on the built environment, this means that someone orders an urban structure […] according to a chosen tradition, which represents, by its formal and material aspects, precisely those things one would like to have others understand as being characteristic for oneself or for one's living conditions. What can be concluded from all this is that the logic of representation obviously requires a direct comparison between products, like buildings or architectural designs […]."

The use of comparative here (rather than as applied to cities earlier) is suggestive of a learning process, which seems concurrent with constitutive phenomenology (Schütz 1967) and can be replicated in interpretive research. Though, at the same time Mekking (2009: 44) admits that (due to globalisation) "never before has it been so difficult to understand the built environment without using a comparative analysis. The signalled, alarming lack of knowledge about the different cultural traditions that architecture forms a part of, has made a meaningful analysis of the built environment as such all the more urgent."

The challenge of comparative analysis alluded to here seems to regard the 'discrete' separation and identification of cultures and societies and not envisioning the urban built environment complex in comparative analyses. This then echoes Dear's (2005: 247) statement made in the light of the conceptual conflicts between the specificity of a place and generalising understandings that "Everyone knows that comparative urbanism is difficult." To his credit, Mekking (2009: 33-24) is mindful of the counterproductive effects of periodisation in historical comparisons as it obstructs dynamic temporality. "Since it consists of sheer projection and has nothing to do with historical analysis as such, one should never use it." Whereas, for example, Robinson's (2004) design for comparative urban research focuses around a specific historical period, which again has the logical consequence that rather than learning about cities, we learn about societies taking place in cities around that time. However, whether culturally or historically specified, all neglect to consider that their comparative complications might emerge from the unquestioned highly specific contextual frames of reference that they tend to use. According to Mekking (2009) for interpreting representative reality one has to know the specific social group who built the architecture, their background and ambitions, so their relationship to preferred specific forms and materials relates to the function and architectural product realised. In other words, his interpretive analysis becomes framed within the symbolism and meaning of shape and material, rather than what its *material presence* implies in terms of social interaction (see **Chapter 2**) and thus the practices of inhabitation and development.

Clearly Mekking's analytical resolution on the basis of culturally embedded architectural traditions operates on the shape itself which is a rather different premise than the structuring properties of the shape of the inhabited built environment proponed here. My critique is not to say that there is nothing to be gained from comparative or generalising understandings of the historically contextual frames of reference in which cities occur and according to which arguably entire cities are shaped. Instead, I argue that understanding cities as a phenomenon occurring within a common fundamentally human process of settling first, would lay a strong rudimentary foundation upon which such contingent meaningful specificities could be better understood since they inextricably cohere with the fundamentally shaping structures that accommodate the messaging or communicating traits. As Kropf (2011: 398) qualifies the built environment: "First and foremost, it is our habitat. The built environment is an essential part of day-to-day life."

It cannot be denied that "[…] a person who is busy creating a dwelling place, uses his or her coordinates and body parts to structure, to proportion, and to orientate this structure[, which is] how people make a meaningful place out of their structure. It is meaningful because one's own body is the bearer of what any place in time means to each builder and inhabitant." (Mekking 2009: 36) So, Mekking goes to great lengths to provide the researcher with a conceptual framework with which schemata of meaning in the shape of architectural complexes can be uncovered comparatively. However, his three clusters (anthropomorphic, physiomorphic, sociomorphic) forming the basic meaningful stratum of built environments forego the solid causal psychological theory to truly substantiate such a proposal on a generic human level.

As mentioned before, archaeological practice regarding the interpretation of the large scale built environments of cities has had the proclivity to focus on architectural traditions and (building) typologies and constructing unavoidably speculative analogies about the potential meaning its incorporated symbolism communicates. Archaeological conduct has assumed *sensu* Mekking (2009: 26) that "expressing something about one's identity is always the goal of ordering or creating an artefact." Rather than always being the intention of creating and ordering, it is an inescapable truth that creating and ordering are as expressive of identity as any activity one undertakes. This notion, however, explains the readiness in archaeology to ascribe meaning to the ordering of places (see examples in Zedeño & Bowser 2009; Bowser & Zedeño 2009). Furthermore, symbolism, as presented in Eliade's foundational thinking, in the explanation of physical city characteristics has since long been a mainstay of comparative urban discourse as initiated by Wheatley (1969). "[C]osmo-magical symbolism […] informed the ideal-type traditional city in both the Old and New Worlds, which brought it into being, sustained it, and was imprinted on its physiognomy." (Wheatley 1969: 9) For example in the Maya area the patterns of urban planning have tentatively been interpreted as 'cosmogrammes' (Ashmore & Sabloff 2002, 2003; Špracj 2009). While my suggestion is not to reduce urban built environment studies to environmental determinism, neither can comparative work be readily supported on the high-level interpretation of largely arbitrary expressiveness (see below).

Environmental determinism

The interpretive claim raised several times so far is that there is a more rudimentary or essential significance in the inhabitation of urban built environments than the contingency and arbitrariness of intentional and artificial communication schemes. One would be forgiven for thinking this alludes to a reduction to law-like determinism in either social or environmental models. Such *sensu stricto* functionalist perspectives would test explanatory hypotheses instead of leading to subjective understandings of living in urban built environments.

This does not withstand that the local geography, topography, climate, material physics, availability of resources and other natural factors will — as society comes to learn about its requirements for inhabiting that environment successfully, sustainably (including the necessities of biological survival), and comfortably — increasingly determine certain aspects of urban form. Moreover, the state of technological knowledge and advancement will physically enable and restrict construction and modification in particular ways. So clearly, neither social practice nor meaningful contexts alone or in combination will fully determine urban built form. There are physical and environmental limitations determining the (im)possibilities of material construction of which and how features can be built and shaped (see also **Chapter 2** on ‘the material’). In other words, there always is a certain level of environmental determinism at play in the processes of urban settling and developing the landscape.

Kropf (1996) acknowledges that natural features and geographical location are of importance in the constitution of the physical properties of the urban form determining the character of a town. After all, anyone visiting a town or looking at their plans will recognise the enormous influence natural features (investigable by comparative positivist measures) have on its general layout, feel and functioning. Conzen (1968) mentions that it is important to include contour lines in town plans, which is a common practice in archaeological mapping, because natural features may result in ‘inherited outlines’ (i.e. persisting shapes) in the pre-urban layout of a developing place. It is essential to understand, however, that despite the influence the presence and physics of the (im)possibilities posed by environmental determinism will exert on the shape of the urban built environment, its social practice opportunities are dependent on the basic properties of the material and spatial configuration constructed as a result, incorporating any natural topography.

No matter the restrictions imposed by environmental determinism, the specific configuration of the built environment is necessarily socially significant, because any built environment is the product of constitutive human and social interactions. Moreover, Deligne alerts us to the risk of overestimating the restricting influence of the natural environment in the development of cities and new towns (PhD thesis 2003, cited in Taverne 2008: 184). It is thus suggested that building according to will, in whatever way man pleases, is quite resourceful and resilient. This supports the view that all built form is emergent from and constitutive of the social (see **Chapter 2** on ‘the social’). Even if due to environmental factors there are true impossibilities imposed on e.g. the orientation, location, or specific composition of any built feature, the spatial results of dealing with that are socially constitutive all the same. The features that are eventually built and the features that are eventually incorporated are still part of a socially significant built environment with a view to accommodate (restrict and enable) social (inter)actions as a contiguous locus. As soon as anything is built it becomes a social reality in the inhabited (urban) built environment. Building is immediately a social act and therefore any shape resulting from it is instantaneously a social reality. The social significance of the basic properties of the material and spatial configuration of an urban built environment can therefore always be studied without having to consider the exact nature (influence) of the environmental determinism at play, although a full narrative explaining the development of a place (a city history as described by Rutte 2008) would be expected to take this into account.

Low-level meaning (avoiding conflation)

Now we can return to the kind of interpretive analysis implied by the process oriented and social practice perspective within the definition of urbanism presented earlier. I have just argued that within environmental determinism and the biological sustenance of its inhabitants, i.e. pure (rational) functionalism, the effects of designing and shaping one's environment are nonetheless socially significant. Furthermore, I have exposed the problems arising from launching comparative research from highly specific contextual perspectives. It is paramount that all building affects how the landscape is experienced and is conducive of subsequent interactions within it. In material records of the built environment (in the archaeological sense) we have a record of performed actions, but no direct ways into the psyche[9] and the contingency of cultural understandings. Yet, the reality of the presence of intentions and socio-culturally specific backgrounds cannot be denied and indeed necessarily plays a role in the decisions to act and appropriate a landscape for inhabitation. Such contextual approaches represent a distinct level of investigation, however, which is contingent on the opportunities created by the more basic material spatial structuring of the life-world within which the conditions, determining the flexibility of the foundations, for the emergence of the imaginative productions of space (see Lefebvre 1991) and representational traditions.

The comparative interpretive objective of this research is therefore to occupy a position between vulgar empiricism or law-like functionalism (based on assumed objective measures) and representational meaning. It looks for the implications of the constitutive material presence of inhabiting a landscape being developed according to human design. This interpretive focus roughly corresponds to what has been called 'low-level meaning' in Rapoport's (1988, 1990) work on the built environment. This

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[9] Although it is possible that psychological functioning eventually is the primary determinant of spatial and social behaviour, the individual circumstances that lead to decisions could still not be fully known and taken into account. Psychology limits insights to individual cases and situations, while a social perspective can assume the constitutive relevance of individualism in decision making processes, but is able to assess and appreciate the complex of outcomes within socio-spatial contexts. In the words of Merton (1936: 896) "Psychological considerations of the source or origin of motives, though they are undoubtedly important for a more complete understanding of the mechanisms involved in the development of unexpected consequences of conduct; will thus be ignored."

mainly conveys recursive human-environment relationships (Smith 2007). In addition, here it intends to incorporate the experiential knowledge this interactive practice acquires and the way it conditions opportunities to develop a 'sense of place' (cf. Tuan 1977; Pred 1986) and an inhabited identity as subsequently introduced in place formation, are implicitly always included, which better correspond to Rapoport's 'middle-level meaning'. Finally, 'high-level meaning' refers primarily to cosmovision and the supernatural. It should be noted that representational meaning, as promoted in Mekking's (2009) work, and indeed regularly seen in archaeological interpretations of urban planning and architecture (e.g. Ashmore & Sabloff 2002, 2003; Atkin & Rykwert 2005; Špracj 2009; critique: M.E. Smith 2003), concentrate on the middle- and high-level meaning. Importantly, the specificities of power, communication, and ideology placed in the realm of 'middle-level meaning' are the subject of research there. As Smith (2007) reflects, except for a slowly increasing engagement with techniques that are primarily empiricist in nature, especially some types of spatial analysis from other disciplines (see Fisher 2009; Cutting 2003, for adaptations of architectural built environment methods), low-level meaning has received little attention in studies on ancient urbanism or long term comparisons.

A potential caveat in Rapoport's (1988, 1990) levels of meaning is its predominant focus on design and planning as it does not discuss what the spaces created by built form are actually used for. It could be argued that the use of space, in a utilitarian sense of particular functions, is part of the response to and intentions for space within the three levels of meaning. However, we can turn once again to Mekking's (2009: 24) discussions on what the built environment represents to understand how this is also intrinsically different and rather elusive on a space and shape level.

> "[…] new functions are initially always represented by architectural shapes which were not explicitly designed for it. […] Referring to the functional side of architecture is nothing more than mentioning just another reality represented by the medium. Trying to discriminate between building types on the grounds of their functional aspect means using the term 'building type' in an improper way, since all architectural typology is exclusively based on formal aspects. In some cases, the function of a specific group of buildings and its (formal) typology seem to match so perfectly that one would be tempted to see it as a 'natural' and 'unavoidable' combination."

This sharp statement brings us to realise a significant difference in the type of information we are presented with. Our responses to and contextual understandings of the shape of built form do not necessarily also prescribe how it was used, as there are many utilitarian opportunities enabled by the same spatially framed interaction opportunities (see also Fletcher 2004; Sayer 2000, **Chapter 2** will develop this notion of spatial independence further). Yaneva (2012) argued similarly with her insight that too often cities are assumed to have common utility features within differing cultural contexts. What actually occurred in specific spaces is only accessible through other types of information, different from the basic material and spatial properties of the complex composite configuration a built environment offers to researchers. This is indicated by Mekking's 'formal aspects' of architecture, which is incidentally primarily what is used by Rapoport (1990) also. It should be repeated, however, that following the cited argument by Andrews (1975) above, this research will not include the material properties to do with style, which are essentially a secondary aspect of constructing a spatial composition.

Composition has a constitutive structuring role of which Batty (2009: 194) recently said: "Currently there is considerable confusion about the way that the physical structure relates to human behaviour." Surprisingly, such fundamental role of built space is recognised by Mekking (2009: 41): "All over the world and for ages now, people have found their own ways to distinguish between 'them' and 'us.' In architectural terms, it mainly means erecting walls to include 'those who belong to us' and exclude 'those who do not belong to us.'" This role of *seclusion as a primary operative* for conceptualising the built environment will be elaborated on in **Chapters 4** and **5**. It forms the tenet of unified way to discuss spatial organisation (cf. Rapoport 1994). Separating use from a fundamental structuring role not only clarifies the information we are after, it also increases comparability across datasets. This especially applies to working with mapped representations of original empirical data, which is significant for achieving the comparative interpretive aims.

Placing a non-utilitarian limitation on interpretation can thus explicate how the interpretive objectives are commensurate with the empirical information employed in research. Lynch (1981) noted that using commonplace (often cultural) terms for architectural objects leads to conflation in understanding. He uses the example of a church to demonstrate that a church is at once an architectural template and a function. The word church may be associated with the particular building once built with the intention of fulfilling religious expectations and taking on a predetermined socio-cultural role, but the way it frames interaction socio-spatially, as a socially positioned spatiality in the built environment context (see Vis 2009), permits wider possibilities. In order to clear up the confusion Batty (2009) signalled and let the social practice perspective on urbanism facilitate a spatial practice analysis to study constitutive society-space relations comparatively and historically (see Griffiths 2013), we need to carefully disentangle which information allows for interpretive claims on what level. Disentangling our information source so it fits the interpretive aims may prevent the conflation caused by the uncritical use of commonplace and lay terms (see **Chapter 2**, especially Sayer 1985). Disentangling effectively means devising conceptualisations able to account for the breadth of diversity of human settling practices under scrutiny, which in this study comprises all urban traditions. Doing so can yield informed understandings of differences and similarities in patterns and processes when applied broadly.

Yet, conflation is not only confined to the cultural embedding and scope of the interpreter. The framing of the objectives of research also causes research outcomes that are themselves conflated or at least confused. When Wheatley (1972) identified the fashionable approaches to urbanism (discussed above), he also noted how these appeared to concur exactly with Tilly's (1967) categorisation of contradictory conceptions of urbanisation. Where Tilly comments on the lack of attempts to define urbanisation as a process, Wheatley condemns a lack of attention to urbanity as an overarching context or phenomenon. The result is that in the absence of clarity and the uncritical use of these terms researchers tend to include too much in their concepts (Tilly 1967). The resultant research perspectives inhibit the development of comparative urban studies (Wheatley 1972). Rutte (2008) demonstrates that urban historians have been particularly prone to be unselective in their research objectives, leading to often uncritically totalising explanatory narratives (see also Diederiks 1976; e.g. Speet 2006) in which inadvertently various aspects of urban life and the city itself are neglected or overlooked and in which it becomes difficult to connect the claims to the information source. This 'purposive conflation' of urban history has also had similar effects for urban morphological accounts of cities (see Kropf 2009).

Research practice

A low-level meaning approach is intended to prevent these kinds of conflation through the consequential requirements of understanding the information source and identifying the commensurate interpretive scope as well as appropriate conceptualisation. For that reason investigation can neither start with pure objectifying analytical empiricism to be compared with and discussed through theoretical frameworks, nor can it start with uncritical culturally embedded empiricism using conflated terms to frame research.

However, this requires a process of knowledge production which allows the empirical record on the basic material and spatial properties of the complex composite configuration of the built environment to speak for itself without relying on positivist measurements for interpretive ordering or requiring elusive high-level representational contexts for its interpretation. Both have undeniable uses for the construction of the full narrative of the life and development of cities, but here the conscious choice is made to limit research to a social practice perspective of urbanism.

While in archaeology the empirical, functional, and representational interpretive paradigms seemingly have been going hand in hand, they do so somewhat uncritically. In part this might be due to purposive conflations, possibly resultant from other urban disciplinary influences, and in part this has been the case due to a lack of appropriate and comparatively commensurate intra-city and wide coverage datasets on ancient cities. Although it is not justified that comparative urban geographical discourse has been ignoring the data that archaeology has been assembling on cities all over the world for decades (Smith 2009b), it can be acknowledged that only in the last decade technological advancements and traditional long term field mapping projects have been producing datasets at such resolutions that everyday urban life and development can be studied properly (see e.g. Evans et al. 2007; Marcus & Sabloff 2008; Hutson et al. 2008; Sinclair et al. 2010; Chase et al. 2011a; Arnauld et al. 2012). The diversity on display is huge and ever increasing, emphasising the enormous potential for broadening and contextualising our contemporary knowledge of urbanisation and urban life.

Perhaps unsurprisingly, it is from archaeological discourse that appeals are made for developing systematic and rigorous comparative frames of reference with direct relevance to social scientific issues and that attempts emerge to come up with methodologies with wide comparative merit to the built environment on various scales (e.g. Smith 2010a, 2010b, 2011a, 2011b, York et al. 2011; Stanley et al. 2012, in prep.; Isendahl & Smith 2013). Currently comparative analytical tools and measures are predominantly adopted from other disciplines, such as architecture and geography (see selected examples in **Chapter 6**), or are driven by juxtaposing an increasing number of urban cases, i.e. become exclusively empirically informed. Nevertheless, it shows that now is the time to overcome the obstructions caused by archaeologists' meticulous and particularist empirical research processes, which detracts from the formulating the frameworks, questions, and perspectives to guide the analysis of these datasets beyond crude quantitative variables on small selections, and stretch research to city-wide (recent attempts e.g. Magnoni et al. 2012; Richards-Rissetto 2012; Hare & Masson 2012) and comparative scales (e.g. York et al. 2011; Stanley et al. in prep.).

Hägerstrand (1976: 332) gave us an insightful view on the importance of everyday individual lives in relation to understanding case studies of bounded wholes, here cities, which display a complex of togetherness in occurring features in time and space.

> "Actually what is at stake here is not in the first place the understanding of unique areas of the world but a deeper insight into the *principles of togetherness* where-ever it occurs. But these principles, as I see it, can only be derived from a careful study of actual individual cases. Such cases need not be of any particular scale, but […] I believe that the small settings — say the daily range of people — is of crucial importance to look into for revealing insights that can later be applied to wider areas. More important than the spatial scale is the treatment of process. Togetherness is not just *resting* together. It is also *movement* and *encounter*."

Against this background quantitative analytical tools should be used in an exploratory and directly interpretive way for individual cases, which due to its formal nature can later be used for systematic comparisons. This requires a basis of careful theorisation of data (**Chapter 4**) as well as human phenomena (**Chapter 3**). The influx of theoretical criticism in Geographical Information System (GIS) science (Leszczynski 2009; Kwan & Schwanen 2009) is leading to an increasingly balanced conduct of hypothesising and exploring landscape perception in GIS applications (Wheatley & Gillings 2000), aimed at generating e.g. human sensory (e.g. Llobera 2003; Paliou & Knight 2010; Smith & Cochrane 2011), affordance and phenomenological (Gillings 2012; McEwan & Millican 2012), and socio-political (Lemonnier 2012; Kosiba & Bauer 2013) understandings. This research eventually utilises quantitative GIS tools and considers appropriately defined comparative measures, the practice of this is discussed in **Chapters 7-9**.

Exciting possibilities are emerging, but the disciplinary context and conceptual perspective sketched in this chapter is in desperate need of a method particularly devised as appropriate for its resultant comparative interpretive objective. This cannot forego a commensurate social theory, as suggested by Yoffee (2009), but will at least need to satisfy Smith's (2011b) *empirical theoretical* requirements to be applicable at all. Neither should it follow any particular disciplinary discourse, possibly finding its most comfortable fit in the inherently interdisciplinary space of urban studies. After all, the aim is to *stop thinking about cities and in cities, but start thinking on cities and engaging with cities* as they occur to us and are developed through inhabitation (cf. Zimmermann's (2012) and Löw's (2012) *Eigenlogik* approach cited above). The material and spatial information contained in the built environment is both the most enduring and ubiquitous source available to us to start this comparative pursuit from. The first focus of comparative understanding (low-level meaning) available to the interpreter refers to its occurrence and presence in the urban life-world. That is, how its emergence from, existence within, and accommodation of social practice is significant to societal structure and development. The omnipresence of the material reality of built environments as a constitutive part of social practice merits further attention, whether its shape is partially or primarily driven by either potentially measurable natural and environmental, functional, or communicable ideational factors. Through this focus my aim is to enable research in the remit of comparative urbanism determined by Nijman (2007: 1), which is to develop "[…] knowledge, understanding, and generalization at a level between what is true of all cities and what is true of one city at a given point in time. […] Comparative urbanism […] is the systematic study of similarity and difference among cities or urban processes."

The potency, cogency, reliability, and relevance of this new comparative method all depend on a foundational philosophy of science capable of providing the basis for both theory building and an appropriate epistemology. This is the topic of the following chapter which appropriates a critical realist view for the purpose of conceptually creating knowledge about the world.

CHAPTER 2 – APPROPRIATING A PHILOSOPHICAL FRAME

Introduction

The preceding chapter embedded and specified the objectives of this research in various strands of disciplinary conduct. In order to make a contribution to the comparative social study of inhabited urban built environments appropriate theory and conceptualisation are needed, which can inform the formulation of a proper method. Taking a fundamental view on urbanism as a human and social process and having considered the pitfalls of reductionism and particularism, low-level interpretation has been specified to ensure a productive comparative contribution. This chapter therefore has two main tasks. On the one hand it needs to take an epistemological stance from which a research practice follows for theorising and conceptualising the substantive field of interest. This requires establishing a workable link between the external reality and conceptual understanding of the world, because through empirical information on the built environment the ideational is not immediately accessible. On the other hand it needs to define a number of metaconcepts which inform how and on which level of detail in **Chapter 3**, departing from an existential premise of Heideggerian human being-in-the-world, fundamentally human and social processes are understood. To this end this chapter will discuss how relating to a particular philosophy of science, critical realism, helps us define the metaconceptual realms of 'the social', 'the material', and 'spatial (in)dependence' as premises on which to formulate concepts appropriate to urbanisation and the resulting urban life as such a human and social process of inhabitation. This replaces the static notion of the city as a category or the concrete particulars of social life in a place and it must refrain from the exclusively separate considerations of the physical, spatial, or social in historical process. Defining the social, the material and spatial (in)dependence clarifies how these are constituents necessarily theoretically incorporated in the temporality of the experiential and affective process and composition of our human life-world while we change and develop that world to live in.

Ultimately, the critical realist inspired thought in this chapter lays the basis for theorising our *a priori* conditions of being-in-the-world and our experiential knowledge of the inhabitation process (**Chapter 3**), and how the information concealed in the built environment (our object of research) can be unlocked intellectually and guide the study of instances of the concrete urban phenomenon for a deeper understanding (**Chapters 4** and **5**). So, it will transpire how from the substantive scope specified earlier a contribution to the broad field of comparative urban studies can be made. This chapter will not yet reveal exactly which essential socio-spatial role the built environment plays in the process of inhabitation, which is the subject of subsequent theoretical assessment, but its articulation of a research practice of immanent theoretical critique and iterative abstraction will determine how we can progress from conceptualisation to the empirically retrievable relevant aspects of this process. This forms the philosophical grounding for the analytical concepts in **Chapter 5** which eventually can be operationalised by method and technique.

Philosophical position

Various sections of the conceptualisations forming the theoretical principles of the methodology being developed by this research were well underway before the remarkable resemblance and resonance with critical realist thought and adapted practice dawned upon me. My fortuitous introduction to Pratt's (1995) human geographical recapitulation made me aware of the relevance to the social study of spatial phenomena this philosophy of science has. The logical effect of this timely realisation is that critical realism now permeates the stages within this research as the philosophical 'underlabourer' it has positioned itself as (see Pratt 1995). Critical realism presents cogently developed ideas, especially processes and methods, for research that are suitable for substantive social sciences (Yeung 1997). In particular the way that critical realism helps to navigate the space between interpretive aims and empirical enquiry provides a frame of reference here. Therefore, my position towards and my use of critical realist thought, especially as adapted within the discipline of human geography, will be discussed. As said, in so doing, this chapter does not only present the skeleton of the research process adhered to, importantly it also clarifies what is and what is not to be part of the nature of this particular process's knowledge production. In other words, what can come to be known by employing its metaconcepts.

As an archaeologist it is relatively easy to acknowledge that there are many processes in the world that pre-exist us (both personally and as a species). Extending that notion logically leads to the acceptance of the existence of an external reality. That is, a reality external to ourselves. The empirical reality of knowledge of things that pre-exist us, however, is restricted to ourselves, which is an argument often used in discussions of knowledge in 'postprocessual' archaeology (see e.g. Fahlander 2012; Wallace 2011). Knowledge therefore is only ever limited and it is questionable whether external reality is ever fully knowable as this would demand of us to transcend the limitations of our own being. Conceding to the existence of an external reality, as first assumed in archaeological empirical practice, reconfirms this research's place in the realm of realist philosophy. Yet, realist philosophy exists in various guises with its respective qualifiers.

Previously (Vis 2009), I have concurred with the reasoning of Putnam's (1981, 1990) internal realism as a moderate version of relativism: things can be true within conceptual confines, opening the way to formulating plural truths about things that exist side by side. Within the current research, however, this needs further specification. Critical realism's stance is represented by the conviction that although plural truths and outcomes may exist the validity of these truths is not equal. The 'practical adequacy' of knowledge would be more enduring when applied in real life if it approaches external reality closer (Sayer 1993; Pratt 1995; Yeung 1997). Putnam himself later shifted from his internal realist position to a 'direct realism' inspired by an advanced interest in human perception (Farkas 2003). Critical realism leaves open the possibility of a 'direct awareness' (Yeung 1997), which seemingly concurs with this idea of the direct perception of external reality. Critical realism, in turn, rather comments on the adequacy of conceptualisations and how they inform research.

Making sense of this within the confines of this research, which was *not predetermined* by any of these ideas, it appears that internal realism could be said to be of relevance in the way that it may refer to the substantive domain in which this research is interested and which is necessarily an abstracted and partial knowledge of the world. Critical realism provides a philosophical ontology which facilitates the formulation of epistemologies of substantive disciplines (Yeung 1997; Sayer 2013; Cox 2013b). The way the substantive domain forming the discipline is conceptualised, here the social science of the inhabited built environment, identifies and informs the aspects to study, which forms an internal realism of sorts, which can be criticised for its practical adequacy. This research also concurs to an extent with 'direct realism' or 'direct awareness' in how it conceptualises human *being* phenomenologically (see **Chapter 3**). Direct awareness could be defined as the origin of our experiential knowledge: what we self-referentially and experientially know to be true. It thus forms part of the condition of human being and all associated causalities, but the knowledge within direct awareness is not directly recognisable as empirical phenomena externally. In the case of the inhabited urban built environment it could be said that we know cities to fulfil the expectation of social life in flux occupying its spatial form. A deeper, emancipating understanding of the nature of the inhabited built environment depends on a practically adequate conceptualisation of it, rather than such situated understanding (see Sayer 1985, 1993). Thus, all of our knowledge cannot be reduced to experiential knowledge, but it would be misleading to not acknowledge its instrumental position in everyday life.

Geography and archaeology

The inhabited built environment as a substantive domain places this research firmly between various academic disciplines. Especially the spatiality of social life as studied in human geography and applied in planning and the materiality of social life as studied in archaeology (and anthropology to some extent) and formally applied in architecture. As this research pursues understanding and analysis, its first allegiance is to human geography and archaeology. Roy Bhaskar's realism was originally intended to ground both natural and social sciences, but its adaptations in social science logically spurred on the debates in human geography with its most notable proponent Andrew Sayer (see Sayer 1981, 1985, 1993; Layder 1988; Duncan & Savage 1989; Cox & Mair 1989; Lawson & Staeheli 1990, 1991; Chappell 1991; Pratt 1995; Yeung 1997). Its critiques were aimed at postmodern and Marxist traditions in interest fields such as labour and capitalism, whilst its methodological pointers were typically aimed at the vestiges of traditional social scientific research, such as interviewing techniques (e.g. Pratt 1995). After over a decade of relative silence, interests in critical realism are making an open resurgence in geographical theorising (e.g. Massey 2005; Jessop et al. 2008; M. Jones 2009) and very recently even the old debates have made a reappearance (Cox 2013a; and comments and reply: Sayer 2013; Pratt 2013; Cox 2013b). These debates do not contravene that in social sciences in general critical realism and its influence seem to have become a mainstay (e.g. Archer 1995; Sayer 2000; Groff 2004; and recently *MIS Quarterly*, 2013).

It should be noted that the critical realist discussion instigated by Cox (2013a) is limited to a critique of scientific conduct from a capitalist view of society, which requires the acceptance of many assumptions made through this theoretical prism on society[10] and logically not tackled topically in (critical realist) philosophy of science. The presumed inadequacies of critical realist modes of thought (Cox 2013a) appear primarily a victim of the mismatch between producing knowledge through a model of society and a flexible scientific model aimed at studying the social (see Sayer 2000). This research is not concerned with capitalism and as such has little to gain from this particular renewed discussion on critical realism in human geography. However, as is clear from Sayer (2013) and Pratt (2013), there is still ample scope to produce human geographical knowledge through critical realist engagements, and this study adheres to that.

In contrast to human geography or sociology, archaeology seems to have steered clear of engagements with critical realism. Though roughly coinciding with its resurgence in human geography Sandra Wallace's (2011) *Contradictions of Archaeological Theory* appeared. Within human geographical discourse critical realism is tied to postmodernist critique and tightly wed to the development of social scientific methods and emancipatory knowledge (Sayer 1993, 2000; Pratt 1995; Yeung 1997). It is too early to tell whether this first archaeological interest in critical realist thought will receive further attention and spur on branches of archaeological theorising, but it certainly seems an opportune match.

The archaeological discipline has been caught in post-modern (and possibly what people currently call 'post-post-modern') tribulations for a few decades, taking a relativist stance of acceptance (Fahlander 2012) — communicating dispersed ideas without overarching epistemology was aptly dubbed 'the tolerance trap' by Wiseman (2011; *sensu* Dervin 1993) — that seems to have grown out of 'processualist' concerns with the particular. Bintliff & Pearce's (2011) poignant title alludes to a 'death' of theory, but actually shows how tolerance leads to the somewhat uncritical embrace of theoretical eclecticism (see Vis 2012, for some critique). So, archaeological theory and

[10] Vis (2010) shows how various assumptions about capital and the subjective motivation to act (economically) challenge mechanisms assumed by Cox (2013a) without his historical materialist explanations for change, while the conception of the acting subject (Vis 2010) is much closer to the one that will be presented in this research which in turn in its comparative aims has nothing to gain by adopting a prescriptive capitalist view of societies. Change is propelled by the mismatch of expectation and outcome, due to inescapable limited knowledge of reality, and the deceptive conformism of the everyday resistance of subjective partaking in society's imposed spiel and the accumulating experience of that (cf. Vis 2009; Vis 2010).

associated practice seemingly mirrors the situation in the social sciences (Groff 2004; also Sayer 1993), which indeed ripens the time for an intervention. In archaeology the theoretical preoccupation with paradigmatic discourses and metaphysics (cf. Bentley & Maschner 2009b; Bintliff & Pearce 2011; Fahlander 2012) is detaining the discussion on how we actually proceed to work with archaeological material *sensu* Smith's (2011a) empirical theory. Wallace's (2011) plea is welcome because she argues how archaeology can be opened to a more comprehensive alternative to the counterproductive postmodern tendencies beyond its useful critiques (see Sayer 1993; Fahlander 2012) within a critical philosophy of science which directly engages with empirical information.

Wallace's (2011) efforts to install a corrective in archaeological practice to position itself as a social science, result from recognising archaeology's fallacies and contradictions stemming from thought developed in a split discipline: empirically bound with social interpretive aims. It is not within the interest of this research to engage any deeper in the philosophical criticisms. Instead, it is deemed more productive to explain how tenets of critical realism have facilitated the process of this research. Critical realism has proved itself to be particularly strong at constructively bridging the divide between conceptual and empirical scientific conduct, which makes archaeology's disciplinary nature a suitable fit for the operationalisation of critical realist notions of knowledge creation. Acknowledging, within this research, that the inhabited built environment only serves as an object of study in its existence as a material record, indeed lends support to the suggestion to refocus the archaeological discipline on its material foundations (e.g. Webmoor 2007), though care should be taken to not recreate the fallacies addressed by Wallace (2011).

Materiality

Despite long and avid debates on the nature of space (e.g. Blaut 1961; Giddens 1984; Sayer 1985; Granö 1997; Blake 2002; Jessop et al. 2008; M. Jones 2009) in human geography, the social sciences, and more recently also in humanities (Griffiths 2013; Arnade et al. 2002), it seems that an active engagement with the material nature of things, the matter that occurs within and shapes space, is strangely subdued. Archaeology is the discipline with most structural traction on the purview of materiality, but its purchase to inform other disciplines of its importance in the spatial debates is arguably crumbling due to the influences of relational and imagined approaches to thinking space (see Blake 2002). Materiality is not completely absent from human geography, however, as shown by concerns to 'repopulate' the world inhabited by humans with the things in our everyday lives (e.g. Jackson 2000; Anderson & Tolia-Kelly 2004).

It is easily recognised that efforts to give material culture a structural position in social and cultural geography resonate well with archaeological adaptations of Actor Network Theory (ANT) thinking into 'symmetrical archaeology' (e.g. Webmoor & Witmore 2008)[11], leading suggestions of taking fully into account a 'more than human world' to incorporate the technical intricacies of human life (e.g. Whatmore 2006). Furthermore, human geographers are showing interest in the sensory responses and making sense of objects' materiality in making place (e.g. Hetherington 2003). Also on a landscape scale, the experience of landscape allowing some role for its material features leads to subjective research in geography (e.g. Wylie 2005) that almost replicates what has come to be known as 'archaeological phenomenology' (Tilley 1994). The affective dimension of the landscape as restrictions and enablement of moving across (designed) spaces with technological objects is studied with more pragmatic aims (e.g. Bissell 2009). Usually, however, these approaches appear to rely on the non-human elements of the life world to be encountered as already constituted objects (cf. Hinchcliffe 2003), despite claims towards a more dialectic understanding (e.g. Wylie 2005). As Anderson & Tolia-Kelly (2004) show, geographers are clearly undecided and still debating the epistemological position of the material, virtually always framing it in immediately meaningful (produced, as in the Lefebvrian (Lefebvre 1991) sense of space) cultural and political perspectives, which largely prevents the material from speaking for itself despite acknowledging its 'capacities and effects'. Yet, the integral perspective on materiality and what it does in the social (cf. Anderson & Tolia-Kelly 2004) is a useful vantage point, but seems to do little else then reacquainting geographical accounts with the mass or matter involved in human—non-human relational accounts of the world.

Amidst the attention paid to materiality in the form of connectivity and relations in performance, choreographical, embodiment, and non-representational oriented geographies (see Anderson & Tolia-Kelly 2004; Anderson & Wylie 2009), Rose &

[11] Actor Network Theory, originating from science and technology studies, proposes that nonhuman objects can partake in social systems, which are envisaged as connected up networks. It studies relations as simultaneously material (things) and semiotic (conceptual), hence symmetrical archaeology. While I pursue a similar position, the conceptualisations in Chapters 4 and 5 are more nuanced, as is my position on permitting nonhuman objects agency (see below).

Wylie (2006: 477) express an opinion derived from landscape geographies which arguably would be most susceptible to an approach giving the material a more active voice.

> “[...] landscape is entanglement. […] But we still have the feeling that, here, a certain topographical richness is being sacrificed for the sake of topological complexity. […] And the result, it can be argued, is a sort of ontological overflattening. […] To put this another way, we are left with a topology without topography — a surface without relief, contour, or morphology.”

ANT adaptations in archaeology run the same risk of ‘ontological flattening’ and materiality has been criticised for being poorly defined and not taking the physical matter of materials into account at all (Ingold 2007). Archaeological discussions on materiality and Ingold’s (2007, 2008a, 2008b) more physically entangled proposals of the fluxes (cf. human and non-human processes (Rose & Wylie 2006)) of which the world consists, lead to propositions for ontological mixtures on the one hand (Webmoor & Witmore 2008) and the world as a meshwork (Ingold 2008a, 2008b, 2011) on the other. Both these ‘worldviews’ make it increasingly impossible to study any object or category, because things end up being defined as indistinguishable, mixtures and entanglements of one and the other. Yet, the longstanding tradition of landscape archaeology (see David & Thomas 2008), due to the nature of archaeology’s exclusively material evidence, can never be completely devoid of the material properties, geometry, substance, morphology, etc. that is inherently part of the topologies we draw from them. Contrary to cultural geography, archaeology cannot choose not to be an empirical science (cf. Anderson & Wylie 2009; Fletcher 2004).

The material

Critical realism’s appropriated prerogative to direct social scientific methodologies overlooks the potential it may hold for a social science on the basis of material evidence, as conducted in archaeology. Logically this cannot go without an initial recording of material properties in order to make inferences on the role they played in the social. Wallace (2011) recognises the important contribution operationalising the material could make to critical realism and, vice versa, on that basis the contribution of critical realism to archaeological thought. Fragmentation in archaeological theorising has been addressed in numerous publications (e.g. Hegmon 2003; Fogelin 2007;

Webmoor 2007; Bentley & Maschner 2009b; Bintliff & Pearce 2011). Wallace (2011) constructs a strong argument for how critical realism as a philosophy of science can help overcome the uncritical multiplicity in archaeological theory. Our concern, however, is not with the philosophical critique and debate, but with the suggestion that, following critical realist thought, the way forward could consist of the construction of *an ontology of the material as an emergent entity*. Wallace (2011) suggest that such an ontology could resolve the contradictions in the theoretical underpinnings of archaeology's paradigms of processualism, post-processualism, and recently, the proposition of ANT inspired 'symmetrical archaeology' (see Webmoor 2007).

Critical realism does not propagate a grand theory, but facilitates the development of disciplinary theory and epistemology. Wallace (2011) points out that although critical realism does not engage with materiality as it features in the archaeological discipline and is also employed here in this present interdisciplinary project, its philosophical role facilitates the building of archaeological theories of the material. As noted before, social scientific and human geographical applications of critical realism to research methods emphasise the traditional social scientific qualitative analysis and engagements with live subjects (see Pratt 1995; Yeung 1997; Sayer 2000). Somewhat ironically what could be called a 'material turn' in archaeological theorising is inspired by relational thinking of similar pedigree as described above for human geography (see Ingold 2007; Webmoor & Witmore 2008; Fahlander 2012). Evidently material should be at the basis of the discipline, contrary to human geography perhaps, and yet Wallace (2011) shows that similar relational influences as in human geography keep the proposal of symmetrical archaeology from a successful treatment of the material as active and constitutive in its epistemology, because of the lack of an ontological status.

In symmetrical archaeological conduct, Wallace (2011: 96-97) remarks:

> "Ontology becomes meaningless as this version [of reality] encompasses everything in an undecipherable mish-mash […]. The amalgamation of all these into an undifferentiated whole would obviate the possibility of understanding the deep underlying workings of reality […]. The logical problem of dichotomisation is therefore solved, but the denial of the ontological reality of the material remains. Although symmetrical archaeology claims to take into account relationality, particularly between people and things, the logical extension of a theory of conflation is that relationality becomes untenable. If there are no separate ontological categories, there is nothing that can be related. Relationality becomes one-

> dimensional, as it refers only to the condition of the ontological mixture of reality."

The ontological mixture of symmetrical archaeology is a counterproductive exaggeration. In order to give materiality a constitutive place in human and social life it is not necessary to equate the material and the social. It suffices to structurally take into account that the material (and its properties) is an inherent part of human and social life. At the same time it is necessary to allow for ontological categories of the material in order to study human phenomena through material records.

"The characterisation of the material as a reflection of the social is the key error of current theorising […]. The material is seen as a distilling or concretation of abstract and non-physical ideas into a solid form that can then be observed and described by archaeologists." (Wallace 2011: 121) In the conceptualisations that inform this research, I use the idea of materialisation when discussing the built environment (see **Chapter 3**; also Vis 2009): physical transformation or modification is the concretisation induced by interaction and conceptual thought. A decision and idea, desire or expectation, has to precede action. However, this does not remove causal agency from the material itself. Materialisation is never a complete translation and always a transformation carried out within the affordances of the material properties previously extant. Although material cannot 'act' or 'perform agency' in the human sense, the *properties of its presence have restricting and enabling causal powers* and therefore necessarily an influence when acted upon emplaced within the human life-world. The resultant material shapes and features, however, are distinct in that they bear the direct evidence of the human engagement with the physical properties of the world and therefore allow for more elaborate interpretive analyses.

The intentions of the performed human and social interactions within the inhabitation of the world have after all led to a material presence, however limited its exact expression of those intentions and relations might be. It is the effects of the materialisation and the subsequent role of its presence in the human and social life-world that can successfully be studied as a dialectic relation. "To acknowledge only effects is limiting in its actualism and does not represent the complete range of agentive properties of the material, especially the basic ontological nature of the material that enables it to be an *agent without intent*." (Wallace 2011: 124, emphasis added;

developed from Fletcher's (2004) material as 'actor without intent'[12]) Similarly in social theory the dialectics of individual-structure and human-material include both the forming or creation of structure/material and the being formed by structure/material (Wallace 2011; Archer 1995). Human beings are emplaced in a material world, which features properties that would exist without human presence also (cf. the furnished world (Gibson 1979) in flux (Ingold 2008a)). These causal powers of these properties are agency without intent (Wallace 2011), which as such can enter into human social interactions.

The agency without intent sets material ontologically apart from humans, who possess intentional agency as an emergent quality. "One of the theoretical strengths of critical realism is the recognition that actualised or empirical events do not constitute all of reality. A deeper reality of potential or unactualised powers exists. The ontological nature of things or people include the ability, whether realised or not, to 'do' certain things as a result of their essential powers and possibilities […]." (Wallace 2011: 129) This level of understanding is where the interpretive power within the research method on the material record being developed here should be sought. Accepting the built environment as a material human creation further adds the understanding of its existence as an outcome of actions being part of the same processes of settling and inhabitation that would be ongoing (dialectically) in the empirical social reality of continued inhabitation and development of that built environment.

As far as material information on the built environment itself stretches, one can only comment on and analyse what actually occurred as that which has been realised in its construction (materialisation), but not what occurred without affecting the material nature of the built environment itself. The role and abilities of the material presence of the built environment when encountered and engaged with in human interactions will be the core of investigation here. This does not withstand the ontological reality of the built environment's physicality without human relations, though insofar as social science aims to understand the social, this research will be restricted to the potential it holds for human and social relations. The physicality which imbues the material its ontological properties and agency pre-existed the human interaction which is where from processes

[12] "[…] the material possesses pattern in its own right, has the effect of constraining options and creating friction, and is also potentially able to undermine viable social life[.] The material is then an 'actor without intent' with which people try to engage. This would create a dynamic in which the inertial and abrasive impact of the material framework on community life is a key agency in the long-term outcomes we see in the archaeological record. [… This] would be a proper construct of archaeological theory." (Fletcher 2004: 111-112)

of modification and transformation the material emerged. This is no different from the critical realist argument for the emergent entities of human beings and societies, which “must obey the laws of physics, chemistry and biology, but as [they are] emergent [they] will also exhibit properties that cannot be explained by the natural sciences.” (Wallace 2011: 148) This concurs with my argument that social science may follow an epistemology that is intrinsically different from natural and positivist standards, because it regards a scientific conduct of members of the same species studying themselves from which different kinds of understandings can be reached (see Vis 2009). This assertion includes an inter-subjective (though necessarily incomplete) understanding of the experiential knowledge we all hold about our (inter)actions with the physicality of the world (cf. Hägerstrand 1984; Yeung 1997).

As an emergent phenomenon (entity) time-space, human interaction, and the physicality of material are internally related as that which is materialised, containing its own causal mechanisms and powers (cf. Wallace 2011: 153). This resonates with my previous arguments for the inherent link between the construction of built environments and the formation of society along the constitutive axes of time, human action and human space (Vis 2009), though, by the same logic as before, not all aspects of the social can become known by its material (physical matter) constituents as materialisation is neither complete nor ubiquitous transformation[13]. “The artefact as observed and recorded by an archaeologist is a physical element of an absent past. The analysis of the object in context can therefore lead to an understanding of the absent social and material existents whose interaction resulted in the presence of the artefact in the archaeological record.” (Wallace 2011: 131) Hägerstrand’s (1984: 377) suggestion of approaching things within a ‘diorama’, leads him to the logical conclusion that archaeologists need to try and fill out a complete story of a ‘once living context’ by interpreting remnants of that continuum. In other words, because the material is an emergent entity the possibility for better understanding is opened by studying aspects of it.

The material as an emergent concept, however, should not be mistaken as a reproductive constant. As argued previously (Vis 2009), to the time-geographical idea of unique position and situation along life-paths (Hägerstrand 1970, 1975; Pred 1977,

[13] This is recognisable in the social as an entity-concept (later in this chapter) and the fact that the nature of investigation of the social, tied to the outcomes of actions and communications, is of a different nature than psychology as inner workings and feeling (cf. Vis 2010 on the outcome of action). The idea of the entity-concept resonates well with the logic of emergence, as it conveys particular causal powers related to the presupposed irreducibility to its constituents.

1981) coupled with De Certeau's (1988) broad notion of performed resistance in the practices of everyday life as drivers for change (even when outcomes of action may look conformist), Wallace (2011: 124) adds: "the conditions for intentional emancipatory change exist in the potential development of a consciousness of the constraining role of the material." Thus, socially speaking, through the inhabitation of the built environment, change is a logical and necessary (inescapable) occurrence, whilst from the physical processes as 'agency without intent' (Wallace 2011) change grows more complex.

The material inhabited built environment

The main message of Wallace's (2011) work boils down to overcoming contradiction in archaeological theorising by positioning 'the material' as an emergent entity and concludes that the development of a full ontology of the material is needed to inform future research. Likewise the human geographical literature on material and matter is in need of an appropriate ontology of the material to work with. It is beyond the scope of this research, however, to fulfil Wallace's suggestion to formulate a full material ontology. Nonetheless it relies heavily on the material as an emergent entity (in addition to human beings as an emergent entity) and recognises that the inhabited built environment could make the basis for an *ontological category* within the material. Efforts will be made to clarify exactly what information and conceptual understanding is contained in the present use of the notion of the inhabited built environment, but not to explain how this differs to other potential ontological categories of the material except for acknowledging the material's much wider relevance.

Assuming the inhabited built environment's material nature, it becomes possible to take *the properties of the material articulation of spatial subdivisions* (**Chapter 4** elaborates) of the composite complex of the built environment as a single information source on a human phenomenon of settled inhabitation that can be studied in necessary relation to the social it is inhabited and developed by, while the physicality of the built environment itself can remain in existence independent of its inhabitation. Thus, the consequences of the material as an emergent entity are brought to bear on this ontological category. This includes a demonstration of the opportunities and limitations created through critical realist thought to productively combine conceptual and empirical reasoning to interpret something that is not or, no longer, present to be observed in the evidence we are provided with. The consequence of this is that such evidence in the contemporary world becomes a candidate for an archaeology of the present. The Winchester test case presented in **Chapter 7** will attest this possibility. Indeed, the basic material notion creates an initially comparative starting point for launching research to better understand this substantive domain.

The *absence* of the directly observable process of *live subjects* and communication implies a limitation to the experiential and developmental potentialities *afforded by the physicality* of the *empirical material*, delimiting the interpretive scope. As the social scientific aim pursued requires viewing the material as if it were still part of a 'live' process of inhabitation (as it would be in usual empirical (observing) social scientific empirical research), it could thus be said that this study is delimited by Schiffer's (1987) c-transforms (and not the n-transforms, i.e. the independence of physicality)[14] shaping the final material presence of inhabited built environments. The focus lies on the stages of material development as bearing witness to the processes that were once going on due to the presence of the (currently absent, or absent from the material information source) social, including the final placement or deposit of spatial-material compositions, though one should remain mindful of the physical processes within the material outside of this selection of human interest (cf. Hägerstrand 1984).

The phenomenon of the inhabited built environment should be seen as a selective (by practice and data), contextual (by an understanding of the urban), immobile (as opposed to moveable artefacts) category of the ontology of the material. This category becomes the substantive domain investigated in this research, which requires its own epistemology, ontology and methods. Although **Chapter 1** situates this study within the realm of social interpretive urban studies, it thus becomes apparent that the inhabited built environment in each particular urban context forms a specific social, spatial, and especially material object of research. Taken to its logical conclusion, critical realist ontological reasoning should be able to determine whether cities, an everyday category (Sayer 1985), as a separate emergent entity would make sense. That is, do cities indeed have a distinct set of causal powers? This research does not claim to provide an answer to that, which would entail, at least from the perspective of the built environment, to say how cities are validated as an intrinsically separate object of study. This is the vantage point assumed by the followers of the *Eigenlogik* of cities (Zimmermann 2012; Löw 2013). The working definition of urban life provided here may well offer a building

[14] C-transforms and n-transforms refer to the cultural and noncultural processes, whereby the systemic context of societies in the material (physical) world is converted into the archaeological context of artefacts: i.e. site formation processes.

block in constructing an answer. I would suggest that the methodology formulated by this research would enable urban studies to assess or identify the possible unique (emergent) properties and processes with regard to the built environment that constitute a particular city as an entity in its own right. Subsequently comparative research could pull out regularities of the inhabited built environment constituents across cities. It is not a given that the inhabited built environment contains aspects of the properties that may render cities unique entities.

Embedding the research process

Now, having established the ontologically material position of the inhabited built environment, which adheres to the inevitable empirical binding of this study, *sensu* archaeology, and its critical realist characterisation, the remainder of this chapter should briefly discuss which tenets of critical realism, "as a philosophical argument about the ontology of reality" (Yeung 1997: 54), will be informing the epistemology and method of this research. This research process should not only lead to a rigorous theoretical framework elucidating the inhabited (urban) built environment, but should allow the identification of analytical units within that phenomenon to open up routes for investigation. Consequently, it requires a process to guide the operationalisation of such elements of analysis into the empirical reality of research practice. It incorporates the progression from selecting a broad phenomenon of interest and identifying a substantive domain of which a specified knowledge is desired. This requires the conceptualisation of the domain and the recognition of how this domain can be studied appropriately in the pursuit of the understanding sought. Necessarily the empirical operationalisation will be limited to constructing knowledge within the scope of the initial conceptualisations. Other knowledge creation would require its own appropriate concepts and ontology commensurate with that perspective, though within a substantive domain these knowledges should be complementary rather than plural or contradictory, unless flaws in the initial conceptualisation of the substantive domain can be identified. As knowledge is inevitably an incomplete version of external reality, the *understanding reached is not a conclusion but a hypothesis,* its endurance determined by its practical adequacy (e.g. applied with emancipating aims and in broadening contexts).

Within this view of the broad scientific process it is clear that the successful linkage between the conceptual and the empirical is paramount. This is where critical realism's meta-ideas about knowledge creation can really help and inform a path towards a constructive research process and method. So far, this study has committed itself to contribute to the understanding of the everyday notion of urban life as an intensive, transformative settlement practice within a particular locus as a long term phenomenon through comparative research. It has selected the built environment as its evidenced substantive domain from the everyday encounter and recognition of cities as a complex of inhabited humanly constructed physical spaces. Furthermore the material nature of this substantive domain has been made explicit through Wallace's (2011) critical realist characterisation of the material as an emergent entity. This selection from a greater interconnected whole is an unavoidable part of the research process, as Hägerstrand (1984) acknowledged, and seems commensurate with a critical realist starting point of research on social phenomena (cf. Pratt 1995; Yeung 1997).

The first step within this research therefore will have to consist of a conceptualisation of the presence of the inhabited built environment, which in effect forms a theoretical understanding of logical coherence and causal necessity that will be assumed as a broad and true framework for the entire substantive domain. As the notions of the material as an emergent entity and the inhabited built environment are new, this theory consists not so much of an immanently critical review (cf. Yeung 1997), but of an immanently critical formulation of reasoning, itself logically susceptible to critical realism's immanent critique. Therefore, following Sayer (1981), the internal realistic tendency expressed at the beginning of this chapter is vulnerable to immanent critique and empirical discoveries, on the basis of which it can be corrected.

While it is conceded here that elements of the processes captured in this theoretical framework could be suitable objects of empirical enquiry themselves — in fact some of them are, e.g. the study of planning policy — the grand, long term and non-society specific or normative, scope of this comparative research would not directly benefit from particular time-space specific engagements, which knowledge would deteriorate its comparative applicability. Effectively it resembles the kind of grand theory or high theoretical order Smith (2011a) appears to forego in favour of 'empirical theories' (cf. Ellen 2010 on theoretical hierarchy). Within the epistemology here, however, the philosophical embedding of the epistemology requires the formulation of this meta-theory to indicate how to construct conceptualisations that can be linked to the empirical evidence which can then be studied within that framework, whilst being explicit about the limitations of the theoretical perspective. Although social phenomena are intrinsically meaningful (see Sayer 2000), empirical evidence on those phenomena, like the built environment, is not intrinsically meaningful to infer the absent social processes without the theoretical framework. It is suggested here that the empirical conceptualisation, however, could be regarded as one of Smith's empirical urban theories in the sociological middle range (Smith 2011a; see also Trigger (1989) for a similar theoretical proposal), and in one sense leads to a low-level thick description.

It follows from the critical realist argument for immanent critique, that a fundamental theoretical framework is first constructed departing from the notion of 'human being-in-the-world'. This will deliberately be kept on a general level of human perception and experience, closing in on the key causal mechanisms (see **Fig. 2.1**) of our encountering and inhabiting the world (see **Chapter 3**), thus installing a temporal, processive perspective instead of concepts as isolated conditional statements (e.g. the idea of man's embodiment or the importance of sensory perception in specific scenarios). A focus on causal processes results in constitutive theory (cf. Vis 2009), which is inspired by Schütz's (1967) constitutive adaptation of phenomenology to enable a sociology of the everyday on the basis of how we come to know the world. The temporality of contiguous processes captured in constitutive theory is important to open up theorising to engage with the long term.

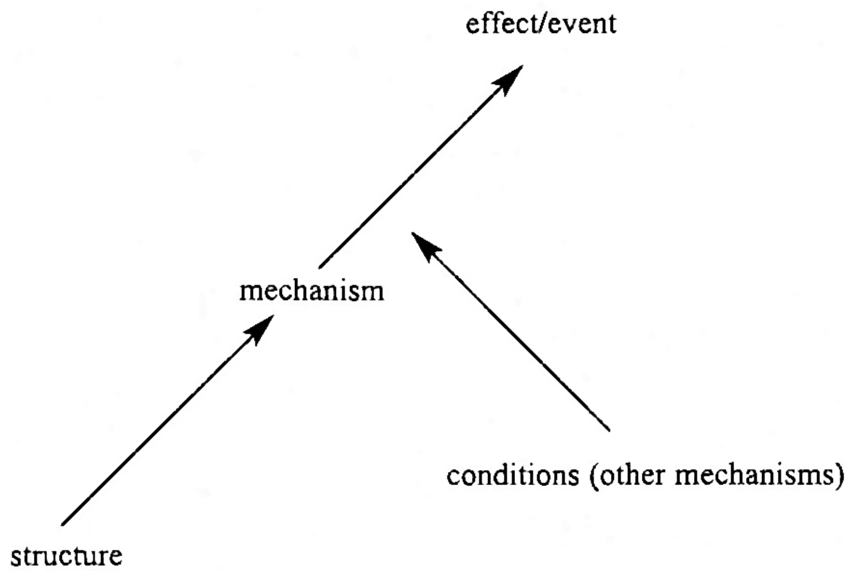

Fig. 2.1: The critical realist view of causation
The critical realist view of causation, notwithstanding the roles played by historically time-space specific contingencies in determining the exact outcome (reproduced from Sayer 2000: 15).

Spatial (in)dependence

Yet, the inhabited built environment cannot be treated within the limitations of a single research project as a concrete object including all the relations and processes in which it is involved, *sensu* Sayer (1981: 7).

> “[...] in order to understand this combination [of all relations], we normally have to isolate each element in thought first, even though they do not and sometimes could not exist in isolation in reality. It's important to note that whether the concrete is observable (and hence an empirical object for us) is contingent (i.e. neither necessary nor impossible). *The concepts ‘concrete’ and ‘empirical’* are *not* equivalent.”

This refers back to the city as an everyday notion rather than a fully understood one, and the limitations of the scientific process despite Hägerstrand’s diorama. Our limitation here is largely due to selecting a specified information source from an observable occurrence: the built environment.

Built environment’s most immediate information source is the spatial composition caused by its material properties (see **Chapter 1**). “Matter *always* necessarily has spatial extention [*sic*] and spatial relations only exist through objects, of whatever kind. To the best of our knowledge, empty space or spaceless matter are physical impossibilities.” (Sayer 1985: 52) In other words, this study will be limited to the ‘difference that space makes’ (cf. Sayer 1985). More particularly it will have to build an ontology of empirically applicable concepts altogether expressing the causal powers of the composing properties of the materiality creating the spaces (the plurality creates a focus on their separation, a necessary condition) of the built environment in inhabitation and development. Despite Sayer’s (1985: 54) assertion that “[a]bstract social theory need only consider space insofar as necessary properties of objects are involved, and this does not amount to very much” it takes full account of his continuation: “It must acknowledge that all matter has spatial extension and hence that processes do not take place on the head of a pin and that no two objects can occupy the same (relative) place at the same time.” The focus of the ontological abstraction of the built environment will lie with the causal powers of the *spatial dependence* (Sayer 2000) of interaction and subsequent development (physical transformation) opportunities.

Logically this dependence is most strongly expressed in the restrictions and impossibilities created by the most durable and pervasive structures (i.e. in the materiality of cities: the built environment), which in terms of the availability of data also implies the relative ubiquity of cases. "[…] structures which are less durable (for example, cultural forms) are too influenced by geohistorical contexts for their explanation to be divorced from those settings." (Sayer 2000: 137) Here the distinction should be made between the large extent to which what actually occurred is contingent upon spatial structures or spatially *independent* (flexible) (Sayer 2000), and the fact that what occurs in space is still accommodated by whatever structure it is comprised of. Contestation of the material properties encountered is inseparable from its part in the occurrence of social relations and any transformations.

The necessity of human encounter for materialising modification and transformation and continued occupation make the role of the material presence of the built environment a necessary causal power, but cannot account for the full causation of change from one developmental stage to another. It is historically contingent which causal powers have played a role in stages of development and the restricting and enabling of interaction (cf. Pred's (1984, 1986) time-geographical development of systems theory in a spatial world), but it is a necessity that the material presence will have had a role. As Sayer (1985) explains, it is not the empirical regularity or universalism that makes events and occurrences a law, but their necessity as mechanisms. But as Yeung (1997: 57) says: "It should not be expected that these abstract causal mechanisms can explain events directly without any need for empirical research into the contingency of the concrete." In Sayer's (2000: 138) words: "Abstraction identifies the necessary conditions of existence of phenomena, but that is different from showing how actual instances of them come into being." In terms of the built environment that means that it may be contingent which constituent element is constructed, but when it occurs it becomes a necessary constituent of the interactions in that locus.

"[…] what theory provides us with is an understanding of the concrete by means of abstract concepts denoting its *determinations*." (Sayer 1981: 9) Abstractions in the theoretical framework imminently presented contain an awareness of what is not further separated and examined. By assuming human beings, their biological, chemical, and physical premises are not questioned, and by its restriction to that which occurred, although not what actually happened *in* space or cities (see also **Chapter 6**), this research will not discuss the cognitive psychology, emotions and decision making processes that lead to the outcomes represented by our evidence. It will thus be assumed that human beings make decisions to act in an ordinally rational way[15], from their unique position and situation with the expectation to improve it (Von Mises 1998; Vis 2010), but it will not question the specific conditions this arises in. Nor will a comprehensive aetiology of society (e.g. Giddens 1984; Archer 1995) be provided as a constitutive explanation (more detail on my view on society can be found in Vis 2009). Instead a rudimentary abstraction (understanding) of the social will be used, which originated as an implicit notion before my engagement with critical realism. This holds that the social concerns everything that requires and emerges out of the co-presence of more than one person.

The social

The collective adjective 'social' is often indiscriminatorily used to pertain to a large variety of societal understandings, which are uncritically presented as distinct. This concerns what could be called realms of the social, such as the cultural, class stratification, politics, economics, religion, etc. There is usually a certain cultured experiential knowledge about these terms as we encounter them in our own lives. In scientific discourse these terms also describe disciplinary fields, yet in much social research they are used as an underdefined concept similar to Sayer's (1985, 2000) layman's and everyday concepts (cf. Fletcher's (2004) concern that generally familiar assumptions could be an inadequate basis for understanding). They conceal the fact that there is no thorough understanding of what each of these realms entails, despite creating a sense of general agreement over what they are as categories. One might be inclined to suggest that these categories are the constituents of the social, the social being an overarching term, but it seems to me that instead they are better regarded as potential foundations of ontological categories of the emergent entity of society. However, the meaningful narratives these categories refer to are contingent upon the social, whereas this research subject concerns the social (interaction) opportunities that are spatial-materially afforded.

This means that the conceptualisations which guide this research will not make an attempt at claiming to uncover meaning within the confines of these 'societal realms' in particular, but rather are claimed to be significant in general for all of them at once. The

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[15] This should not be confused for normative rationality in actors. The unique position and situation of individuals inhibit a complete understanding of their motivations, nor can their motivations ever be judged on their rationality.

term ‘social’ when used here should therefore be seen as an inseparable aggregate, an entity-concept (see **Note 13** above; cf. Vis 2010), in which we know that all these realms may have a part, but we cannot distinguish the exact influence of either one. Moreover, the empirical information source (the morphology of the built environment) and its theoretical embedding, would not in any identifiably necessary way provide access to such interpretations. In other words, for the purposes of this research the potential differences between societal realms do not exist, nor is the potential for identifying specific differences subject of investigative efforts, yet their respective contributions are always implicitly included in any consideration of social relations and interaction. Thus, it subscribes to the assertion that *the social is knowable as an entity of interactional outcomes of which the composition of built environments forms part* and accepts that *the lack of discrete separation puts each societal realm beyond the reach of this research process*. As a consequence its interpretive contributions trade persuasive meaningful narratives for more rudimentary scrutiny (cf. Sayer 2000 on historical interpretation).

Iterative abstraction

Iterative abstraction and grounded theory are two typical methodological pointers in critical realist research (Yeung 1997; Sayer 2000) and actually provide the best results when used in conjunction. The goal is “to discover and conceptualise generative mechanisms” (Yeung 1997: 58) by a process of abstraction closing in on the essential causal power of objects in relation to a concrete phenomenon and helping to distinguish the necessary from the contingent relations between them. When exercised in this research, this process aims to rationally abstract the causal powers of the material presence of the built environment’s morphology in the social processes it partakes in, or differently said, the spatial dependence of what is afforded by the causal mechanisms (here: ‘boundary operations’, see **Chapter 5** and onwards) in relation to the built environment’s morphology. The process of abstraction therefore needs to presuppose the object of study, which here is the inhabited built environment’s morphology, while it should be recognised that abstraction can only elucidate the concrete phenomenon partially (cf. Yeung 1997). Yet, in this research there are several stages of abstraction. The first formulates the immanently critical constitutive theory, which itself explains the underlying understanding of the causal mechanisms leading to the development of inhabited built environments as an effect or outcome. On that basis iterative abstraction and grounded theorising can be initiated for discovering the constitutive elements of material transformation shaping the built environment for living in. An additional exercise of abstraction aims to better understand the abstract representation of spatial data derived from an empirical reality, which provides the epistemological principles determining what we could come to know by studying this data. Versions of these latter two abstractions were initiated before streamlining their structure with a critical realist interjection.

In iterative abstraction, here with the aim to formulate ontological elements redescribing and defining the inhabited built environment's morphology, the collection of unexpected empirical evidence may be cause to revise or reaffirm the initial abstractions made. Although presented by Yeung (1997) as separate instances of typical methodological implementations of critical realism, this work's progressive structure is not served by the formal distinction between iterative abstraction and grounded theory. The process of *retroduction*, moving from describing a phenomenon to its generative aspects and conditions, *sensu* Bhaskar, underlying the process of iterative abstraction here also serves to elucidate the spatial data acquired from the empirical reality of cases. This in turn ensures that the iterative abstraction towards the elements of an inhabited built environment ontology does not occur in a vacuum according to the requirements of critical realist grounded theory (see Yeung 1997, for more detail). Key criteria for successful abstraction (uncovering the real essence) consist of functional equivalence (causal powers) and plausibility (constituent of another knowable entity) of each element defined. The constitutive theory should therefore indicate the mechanism that holds *ontological primacy* (**Chapter 5**) in the conceptualisation. At the same time iterative abstraction contains the possibility of induction as necessary relations can be recognised from the outcomes of actions (cf. Yeung 1997). Minor examples of this will be revealed in the conceptualisation of the inhabited built environment.

When following the process of iterative abstraction, an ontology of empirically applicable concepts is formulated. This conceptualisation remains practically adequate for as long as these concepts can be positively and exclusively identified in the empirical evidence. This latter applied aspect of the process rather looks like grounded theory as described by Yeung (1997). Having established a theoretical framework for the object of interest and conceptualised what of the spatial-material empirical reality is represented and thus what can be known from the data, it can be presupposed that the abstractions are empirically recognisable in the data. It should be noted here that although Pratt (1995) and Yeung (1997) claim that phenomenology is *antithetical* to critical realism, within the theorising of this research that assertion is *not* adhered to.

The empirical induction (from a situated perspective) of which some phenomenological research suffers (cf. the individualistic archaeological phenomenology) should be avoided. Like Lynch's (1981) example of the category of a church, such culturally embedded or historically contextual (often assumedly commonsensical) empiricism causes conflation, obstructing understanding of the concrete in which everything has a part. Church concerns a conflation of space, material, function and performance, and depending on the question of contingency and necessity, obscures the difference between spatial dependence and independence, which is what iterative abstraction attempts to avoid. However, as mentioned before, the focus on causality driving iterative abstraction fits well with the *constitutive* branch of phenomenology as devised by Schütz (1967), which in itself may be able to overcome philosophical disparity with the suggestion of a similar epistemology. Regardless of philosophical origin, the importance of methods "cannot be exercised unless they are supported by strong philosophical claims at the ontological and epistemological levels." (Yeung 1997: 55) Here a convergence of phenomenological ideas about knowledge production with philosophical ideas about the critical realist scientific process emerges.

The character of the continuation or operationalisation (empirical analysis) of the conceptual stages (realist analysis) (see Sayer 2000), is suggested by Sayer's (1981: 9-10) following argument:

> "Good or 'rational' abstractions should isolate necessary relationships. The concrete, as a unity of diverse determinations, is a combination of several necessary relationships, but the form of the combination is contingent, and *therefore only determinable through empirical research. As such, its form cannot be assumed to have already been 'taken up' into the theoretical framework in the same way that the nature of the abstract can.* […] we simply have to go and find out through theoretically-informed empirical research."

This is in logical agreement with his classic critique of urban modeling as a planning solution (Sayer 1979). The consequence of this is that the final stages of this research process are dedicated to an exploration of the characteristics of the identified abstractions in cases of empirical evidence to get to know the contingent regularities and variation in the way they are related in the whole. Only from this exploration can something be said about the ontology of a particular unique city by means of its inhabited built environment.

Exploration is little more than observing reorganised data. “It is now widely recognised that observation is not theory-neutral but theory-laden, and that theory does not merely ‘order facts’ but makes claims about the nature of its object. So, in evaluating observations we are also assessing particular theoretical concepts and existential claims.” (Sayer 1981: 6) Despite the prevalence of qualitative critical realist research, it is conceded that quantitative methods “[…] are particularly useful to establish the empirical regularities between objects. Although these concrete regularities are not causal relations, they can inform the abstraction of causal mechanisms. Quantitative methods are also useful in drawing attention to the external and contingent relations between objects.” (Yeung 1997: 57) The latter emphasises the relevance of quantitative methods for guiding correlative investigations in conjunction with ‘lower order’ concepts (see **Chapter 6** on space syntax).

Ontological abstractions can still benefit from engagement with ‘lower order’[16], more mundane and concrete aspects e.g. house, church, street, park, etc., in research. “These ‘lower order’ concepts are certainly not ‘operationalisations’ of ‘theoretical terms’ (which is how empiricists would see the matter), but different aspects of the object of study.” (Sayer 1981: 13) This opens the way for correlative research which could lead researchers to asking new questions, in turn reaching yet further insights on the concrete phenomenon in its entirety. This is part of the critical realist process of triangulation, where multiple methods are employed. Part of this process can be correlative in either data, method, or on increasingly time-space (historically) specific grounds, while part could also make an effort to define ‘common units’ of investigation thereby expanding comparative grounds for research and strengthening the data work. Given that methods require philosophy and theory, one should take Sayer’s (2000: 147) warning to heart: “In practice the attempt to combine many theoretical insights can easily become unmanageable, and the tendency to slide into ad hoc uses of unexamined concepts […] becomes stronger than usual.” Eventually the expectation would be that triangulation according to critical realist principles, or adding to the initial research outcomes and ontology critically, will eventually improve practical adequacy as the appropriation of the causal mechanism should closer approach the concrete when different facets of the same phenomenon are complementarily integrated (see Yeung

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[16] This critical realist term should not be confused with the low-level interpretation advocated in Chapter 1.

1997). Where additional research is confined to the correlative realm the philosophical position of critical realism as an ‘underlabourer’ could be extended to its operationalisation in empirical analysis.

Finally, abstraction is possible on any scale of the causal hierarchy of emergent entities, i.e. ontological stratification, (e.g. from the individual to the city and globalisation), which does not affect its social significance (Sayer 1981, 2000). Physical shape or spatial separation may not itself be a direct necessity for the constitution of cities, but as a consequence of material differentiation through transformation, which will be demonstrated to be a necessity for making space habitable in the following chapter, it creates form by dividing up space into the composition (form to space, cf. Mavridou 2012) that is the built environment, which is a necessity for city dwelling. However, causal mechanisms, not conditional statements, make a definition of an emergent entity. In the same way an aetiology of society (e.g. Giddens 1984; Archer 1995), containing several levels of emergent entities, is a condition for the urban life in cities, but it is contingent whether a city is developed at all. The necessities of the human condition and the causal mechanisms of inhabiting the world, from which a city as an inhabited urban built environment may emerge, respecting the understanding and limitations within the metaconcepts of ‘the material’, ‘the social’ and ‘spatial dependence’, are conceptually framed in the next chapter.

Ultimately, with regards to research practice, it is concluded here that Bhaskar’s social scientific realism as summarised by Yeung (1997: 52) will be broadly adhered to: “[...] a scientific Philosophy that celebrates the existence of reality independent of human consciousness (realist ontology), ascribes causal powers to human reasons and social structures (realist ontology), rejects relativism in social and scientific discourses (realist epistemology) and re-orientates the social sciences towards its emancipatory goals (realist epistemology).” Despite the solid philosophical foundation of the research process, one should be wary of its inherent risks (roughly following Sayer 2000). First, the inescapable partial focus of abstraction could restrain analysis and understanding unto a reductionist level. While abstraction is reduction, it should not become reduction to the extent that conceptualisations lose the ability to be used meaningfully. Second, identification errors are possible in the empirical operationalisation of the abstraction and thus in the iterative process. This may entail both false positives of a concept within empirical data or missing empirical characteristics to represent an ontologically or causally distinct pattern. Third, one may mistake what is functional (cf. accidental properties, such as often the precise building material used in construction) for phenomena to occur as necessary conditions. Fourth, failing to acknowledge the contingency of 'reproduction' of emergent structures could slide into structuralism. After all, something happening once does not necessitate it happening again. Together with the necessity of change following from the always unique position and situation of an individual, it is unlikely that social phenomena are reproduced in a strict sense, as is a prevalent turn of phrase in social theorising.

Interpretations in conclusion resulting from following the research process developed in this chapter should be seen as the dissemination of analytical outcomes upon which hypothetical narratives could be built. These hypotheses can serve as practically adequate knowledge until they are superseded. Imminently, however, this study directs its attention to formulating an immanently critical theoretical framework for the inhabited urban built environment.

CHAPTER 3 – CONSTITUTING BUILT ENVIRONMENTS, ESTABLISHING BOUNDARIES

Introduction

The preceding two chapters have provided a context to found and specify the contribution intended by this methodological work, a disciplinary position in geographical and archaeological urban studies, defined three theoretical metaconcepts, and outlined a research process appropriate to the object of study: the urban built environment. Together these form the direction and foundation upon which this research is based. The determination of this elaborate embedding is a direct consequence of the domain in which I have expressed an interest by formulating the research objectives, which require to both define the significance of inhabiting *built* environments and how this significance can be studied (**Introduction**). Taking a cue from the conceptual definitions presented in the preceding chapters in particular, i.e. the process oriented, social practice based, working definition of the city (**Chapter 1**), and the metaconceptual definitions of 'the social', 'the material', and 'spatial (in)dependence' (**Chapter 2**), this chapter continues to develop a theoretical framework of understanding based on causal mechanisms. The social theoretical tenets presented here build on an epistemological basis laid in *Built Environments, Constructed Societies* (Vis 2009), which specifically introduced the social systemic and time-geographical ideas taken further in this chapter.

This theoretical framework will place the spatial and physical information that built environments contain within a basic interpretive scope pertaining to the substantive domain defined before (**Chapter 1** on geography and archaeology). The functioning of the social inhabitation process thus captured is directly relevant as the theoretical underpinning of the empirical socio-spatial concepts formulated in **Chapter 5**. It sets out an immanently critical theory of the underlying sequence of causal necessities (**Chapter 2** on the research process) of inhabiting the world, despite the development of a city and urban life being a progressive contingency. The theoretical framework reveals the constitution and process of the inhabited urban built environment. This is how we come to know the elementary rudiments of *what about* the built environment is socio-spatially significant for inhabitation, i.e. boundaries of differentiation. Subsequently, in **Chapter 4** boundaries are conceptually taken forward, leading to a better understanding of built environment information which is usually studied as spatial data. Thus, through the theoretical argumentation in this chapter boundaries become the elementary aspect that characterises the efforts of this study: the basic property of the material configuration manifest in the complex composition of the built environment upon which comparative research and a commensurate treatment of spatial data can be focused.

Reasoning towards a theoretical framework

As explained in the previous chapter (on iterative abstraction), this exercise in reasoning, or thought experiment, forms a first stage in a research process initially unfolding in several steps of abstraction. It presupposes the existence of the inhabited built environment, but attempts to elucidate how this existence came to be by placing it in direct progressive relation to human beings coming into and inhabiting the world as it occurs to us. On no account should this be seen as an absolutely necessary, prescriptive, line of evolution that human existence in the world did or should eventually completely move through. So, the following will present necessary conditions as well as causal mechanisms the operation of which is a progressive contingency. The sequence should thus rather be seen as an exercise that picks up on the processes of settling through which something we already know to exist (cities) can be more appropriately understood as continuing part of those processes. Reasoning through the processes from a necessary starting point to a known end point produces a theoretical framework. As was asserted by Yeung (1997), such abstraction can only elucidate the concrete phenomenon of the inhabited built environment partially, here delimited by the common human process of inhabitation of and settling in the world. This theoretical framework will be in keeping with the low-level *rudimentary understanding* established throughout the preceding discussions and is *susceptible to any criticism that demonstrates that the situations outlined cannot lead to the consequences suggested*.

Importantly, it should be noted that in critical realist terms, this theoretical framework consists of conditional statements without which the consequential stages of development could not be reached. This is not the same as comprehensively revealing the complete necessary causal relations between one situation and the other. As alluded to above, under no circumstance is it necessary that a(n) (urban) built environment is developed and, especially, there are no determinants as to how this is developed, recalling that the world hosts relatively stable nomadic, hunter-gatherer and ‘rural’ village societies. The conditional statements provide the basis upon which a causal mechanism could operate, but it remains contingent on other factors whether this happens. This stage of abstraction is therefore not a product of iterative abstraction as explained in **Chapter 2**. Instead, it concerns the immanently critical formulation of a constitutive theory. Again, this should not be confused with a critical realist’s immanent critique of extant literature, but rather reasoning building on inevitable foundational thoughts created by others which are reworked and placed in a framework which is itself logically susceptible to immanent critique.

Through the theoretical framework it should become clear how to understand the development of the inhabited built environment on a fundamental level and to identify the essential (trans)formative element through which to investigate the comparative information on the object of study available to us, i.e. the urban built environment’s *material morphology* playing an inherent role in and allowing inhabitation. In so doing, the basis is laid for the conceptualisation of this element as empirical information and the process of iterative abstraction to formulate an ontology of the constitutive characteristics through which differing occurrences of the element can be recognised and contextually understood and positioned in the whole.

The condition of being human

Although urbanisation might not be a universal necessity, it is recognised as a cross-cultural and deeply historical repeated phenomenon resulting from the intensive development of places for inhabitation. Despite being historically contingent local formations, cities themselves become constitutive of the development of the societies residing in them. This can be known because the condition of being human does not allow us to extract ourselves, or escape, our being in the world (sometimes expressed as our ‘facticity’ in philosophy). So what, in the context of a constitutive understanding of built environments, is meant by the condition of being human in the world?

The existential formulation as used above is unavoidable. Though it is not asserted here that Heidegger’s (especially 1972) philosophy is *sensu stricto* followed, the foundational character of his ideas as filtered through adaptations by, especially, phenomenologists — amongst whom the constitutive phenomenology of Schütz[17] (e.g. 1967) has had the greatest influence on the thought here presented — is undeniable. To be in the world is manifested through structural linkages with the world (temporal and spatial relations between human being and nonhuman things). Heidegger's argument was that we cannot exist unless we have a world to be in. Existentialist philosophy came forth from the notion that the essence of man follows his existence, captured by our condition or facticity. So the significance of the world to our being in it depends on how we are in the world. The way we are in the world is first and foremost temporally and physically conditioned by our bodies through which we occupy a position in the world. The physical properties of our body relate to the physical properties of the world, while the physical (biological) nature of our bodies intrinsically delimits our time of being through degeneration into mortality.

Phenomenological adaptations in psychological and practice-theoretical anthropology have strongly developed the consequential idea of embodiment following from attempts to overcome the mind-body dichotomy (see Bourdieu 1977; Csordas 1990; Ingold 2000; Low & Lawrence-Zúñiga 2006), which have since gained a persuasive and influential position in social theorising. Through the anthropological proposition of embodiment the human body has become established as a site of lived experience and embodied agency (Joyce 2005). The physical and biological nature of our embodiment is such that we have mental command over our body. This makes our psyche, which incorporates the mental capacity to decide to act, an immediate in our being.

A resultant premise is that human beings act necessarily. Human beings already act by being there, which therefore also comprises the choice not to act (Von Mises 1998). As mentioned before, human beings act rationally, which is not to say that rationality follows a normative pattern. Following Von Mises' (1998) precise action-theoretical formulation of purposeful action, decisions to act are ordinal: someone acts to improve

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[17] In archaeology the original metaphysical (Husserl) and existential (Merleau-Ponty) branches of phenomenology have grown to become much more popular than the here prioritised sociologically inspired constitutive phenomenology of Alfred Schütz. A discussion of how these branches relate can be found in Campbell (1981). The rationale for preferring Schütz's phenomenology results from its strong action-theoretical connection, which through Von Mises (1998) is central to the theoretical arguments here. Furthermore, Schütz's (1967) cogent proposition of a social subject with social experience in an individual life-world, resonates well with the social scientific concerns of this research. It allows a ready connection to a social constitutive or emergent perspective of society in systems theoretical sociology (cf. Giddens 1984), while simultaneously maintaining a connection to the experiential reality of inhabiting a physical world (see also adaptations in Vis 2009).

one's position and situation and prefers to do one thing over another in the expectation of the improving nature of the action's outcome (also see Vis 2010). In Von Mises' (1998: 18) own words:

> "Human action is necessarily always rational. […] The ultimate end of action is always the satisfaction of some desires of the acting man. Since nobody is in a position to substitute his own value judgments for those of the acting individual, it is vain to pass judgment on other people's aims and volitions. No man is qualified to declare what would make another man happier or less discontented."

Von Mises therefore even proposes to reject the qualifiers rational and irrational. Of course, there is no guarantee that the outcome of action is as envisioned. One cannot foresee the outcome of action. In concert with the critical realist emergent entity of human being, man is ultimately biologically and physically restricted in his actions.

Now we have situated ourselves in our bodies, the physical nature of which installs the mental capacity by which we can act, thus realising the perception of bodily being and the enabling effects this has. "Man is in a position to act because he has the ability to discover causal relations which determine change and becoming in the universe. Acting requires and presupposes the category of causality." (Von Mises 1998: 22) The experience of embodiment and its effects fit us into the world simply by being there and the actions we inevitably perform from that continuously changing position and situation. Embodiment alone cannot fully account for our being in the world and the phenomenological bi-implication of man and environment (see Ingold 2000; Kolen 2005). Both being in the world and the bi-implication hold at its core that the body does not only physically capacitate us, it is also intrinsically part of the physical nature of the world. Howes (2005a) has proposed the concept of *emplacement* to express the immediacy of the sensuous interrelationship of mind-body-environment, which requires and presupposes sensory experience. This creates an environment incorporating ourselves that is both physical and social (involving the presence of others) through our causal interactional experiences of it.

Sharing the intrinsic conditions of our nature, *a priori* we have a self-referential intersubjective or empathetic understanding of other human beings, which is necessarily limited to our diverging position and situation and the unique knowledge and experience that are incorporated in it. Self-referential understanding implicates that it cannot be assumed that two understandings and uses of learned concepts are exactly the same. Yet, through converging (increasingly proximate) biographies, fundamentally evolving ephemeral phases and concepts in how we live in the world can become more constant and persistent, which does not contradict the uniqueness of individuals' situatedness within it.

A human being is necessarily conditioned to be somewhere and sometime. Following the principles elucidated by time-geography, through our emplaced being from inception we occupy a time and space and the same space can only be occupied once, while time is exclusive in the sense that we cannot be in two places at once (see Hägerstrand 1975, 1976; Pred 1977, 1981; Thrift & Pred 1981). Consequently, not only because of what we do and experience but also within the world, one's position is always unique. Since our situated knowledge (see Schütz (1967) for essential ideas about how we acquire knowledge) frames the expectations we have about the causality of our actions, it is not only vain to pass judgment on someone else's actions, it is also simply impossible to fully grasp the rationale behind someone else's decision to act. In addition, no action that seemingly conforms to or reproduces prescribed or existent patterns and structures will necessarily have been performed with that expectation or experience of it (cf. De Certeau's (1988) resistance in the practice of everyday life). Understanding and anticipating someone else's actions is limited to what is self-referentially and intersubjectively possible.

With emplacement, situated purposeful action and the causality of this, human being is ready to be in, encounter, and inhabit the world. We first perceive the space we occupy as an embodied being and our senses allow us to perceive our surroundings also. From the experience of occupation through our capacity to act we come to know about the causality of interaction within the environment we are part of and the mutually affecting physical properties and processes. This is both immediate and inescapable. Our being is acting, and consequently each action occupies time and space. Our actions give our being time-space specific particularities. The incorporation of physicality means that any of its outcomes will affect and transform the temporal and spatial properties of the environment (cf. Pred's (1984, 1986) transformation of nature). In this way, following Richardson (2006), "[t]he world […] does not stand apart from us and our actions, but depends on our being in. Through our actions we create the world in which we are, we create to be in our creations." (Vis 2009: 40) In the life-path we are compelled to move through (cf. time-geography), our interactions construct relationships with our physical and social environment, the outcomes of which play a constitutive role in how we subsequently act (see Griffiths & Quick 2005).

Presupposing the existence of others, the formations in which we inhabited the world together (societies) are a specific emergent bundle of human inter-personal (i.e. social) relations developing out of a constant merger of the axes of human time, human action, and human space (these axes were explicitly developed in Vis 2009). As perceivers and producers of the physical and social properties of the temporal and spatial environment we occupy, we both encounter and experience its properties through interaction and can create conceptions of them in anticipation of action and through transversal thinking (cf. representation in Mekking 2009; **Chapter 1**). The human and social production of physical properties in this process thus results from our perceptive and experiential being-in-the-world and our emplaced or situated knowledge of causative actions (see Ingold (2008a) on inhabiting the world). From the moment of the first transformative interaction with the environment, human action as productive and perceptive can no longer be experienced as separated perspectives because they occur simultaneously. Yet, human action is significant from both the productive and perceptive perspective in elucidating the role of the environment in societal development.

The condition of human-being-in-the-world thus inextricably socio-spatially determined, we can now shift our focus to the process of encountering and inhabiting the world. Regarding human beings as socio-spatial beings implies the inherent relations of human beings to the physical properties of space and other human beings. Even though our inhabitation of the world is inseparably social and spatial, it is heuristically advantageous to initially present this process as two divided sequences of constitutive (bottom-up) reasoning: human *being* in the *spatial* world and human *being* in the *social* world. It will demonstrably follow from these sequences that the heuristically separated ways of inhabiting the world are in fact merged as immediately socio-spatial. From the vantage point of the socio-spatial nature of the constitutive processes structurally relating us to the world we inhabit, it becomes possible to gain an understanding of why human beings transform their life-worlds. As the (urban) built environment consists of a complex transformation of the life-world — then the primary accommodating product and scene of social life unfolding over time — such constitutive understanding will allow for the study of the significance of the physical presence of the built environment in societal development.

Essentially this is to ask what it is that the built environment does within the inhabitation of the world. It clearly stands in opposition to a world that is not transformed and therefore does not pose a situation where we live in our creations.

However, to assume that an untransformed environment is an empty environment amounts to a gross oversimplification. Hence the theoretical framework starts with the imaginary (abstract) notion of empty space.

Human being in the spatial world

Empty space

Most people will have some idea about what empty space or emptiness[18] entails. So I can appeal to the reader's imagination of being in a spatial world that is empty. Most probably this will conjure up notions of nothing — the troublesome linguistic concept of nonexistence — on a fundamental level through to empty boxes or empty delimited spaces at the more mundane end. The latter is contradictory as the delimitation of a space indicates the presence of something delimiting in the world. So to maintain the thought experiment we need to assume all-encompassing emptiness, implying there are no confines to or things whatsoever within the environment we are in. It contains no formed entities and no objects. Such a notion of empty space cannot be made concrete and therefore only exists as a metaphysical concept. Our everyday concept of emptiness ends up being like nothing and as an imaginary construct eludes exemplifying. Ingold (2008a) takes after Gibson (1979) when he encourages his readers to think of a stark blue sky without any entities such as clouds when he explains that the absence of textural differences creates the perception of an empty void rather than the surfaces we perceive normally. Thus the essence of emptiness is the absence of differences and boundlessness: an endless void in which nothing exists.

The fundamental problem is that we imagine in spite of ourselves. If empty space would be something with our being in, this would refute its emptiness. Hägerstrand (1984) said that every action is for its outcome dependent on what is present and absent. As determined before, we act by being there. However, if nothing is present there is nothing to be emplaced in, let alone to act within, so action would be without consequence and causality. Empty space thus contradicts the human condition of a continuously perceptive and experiencing being through our encountering the world (cf. Ingold 2008a). With no surfaces to experience empty space would be *unintelligible*: there is nothing to inhabit, nothing to engage in interaction with or to relate to (see

[18] It is acknowledged that emptiness can be a philosophically laden term, but it is felt that the argument here is helped by appealing to an intersubjective or commonsensical imagination of empty space.

Table 3.1 below). A way to make the notion of empty space concrete is to imagine a world unaffected by human presence; a world which no human being before inhabited. This kind of emptiness will be captured in the concept of primordial space.

Primordial space

Ultimately primordial space is an abstract notion (like empty space) as we cannot (re)construct a situation in which the world was not affected by human presence before. As soon as we place ourselves in such a world, essentially the world is affected by our presence, but we can nonetheless imagine a situation in which the world occurs to us without human presence. This can be seen as an abstracted perception of the world we would encounter in the imagination that no human would inhabit it, while it contains everything we would otherwise perceive and experience. This idea is close to what Ingold (2008a) calls the 'as if' world. This is the same assumption we make every day when thinking about the properties of the world as something remaining in existence when we are no longer present to experience them. Primordial space is imagined, but includes all the features that set the scene for potential habitation. This scene refers to Gibson's (1979) 'furnished environment', which comprises the textures, substances, objects, etc. that 'afford' us to interact with the world from our emplaced situation.

Affordance, originating from ecological psychology, is academically still a contested concept, as differing ideas about its relevance and nature persist (Jones 2003; Costall 2006). Broadly speaking, in this research affordance appears as conceptually close to Gibson's (1979) original proposition: the opportunities offered by and consequences of acting upon the physical properties of the world. Affordance is separate from the perception of objects' substance and surface properties, because it concerns the action centred implications of their presence[19]. The notion of emplaced lived experience (Howes 2005a) tentatively brings these two positions close together. Primordial space as a world with affording furnishings can tentatively be exemplified.

Primordial space as just featuring affording furnishings may resemble the landscapes we normally regard as wild and natural, that is, not cultivated and inhabited by human beings (cf. Deleuze 1984), which is usually not unlike big natural reserves. One should be careful with such assumptions, however, as what appears wild and

[19] An operationalised views of the concept of affordance can be found in discussions on materiality, e.g. Knappett (2004, 2007) and Ingold (2007, 2008a, 2008b) and related ideas discussed in Webmoor & Witmore (2008) in material culture studies in relation to the technological focus in ANT.

untouched is often deceptive. Since we can understand the (deceptive) experience of not recognising human presence due to the apparent absence of (traces of) physical transformations, the primordial world is made imaginable and intelligible as such. Emplaced lived experience generates an understanding of opportunities to use, and the effects of interacting with, the furnished world's physicality and resources. Regardless of the (past) presence of others, primordial space then could encompass Ingold's (2008a) 'life in the open world'. Ingold explains that the world and all it contains is in continuous flux, a world entirely composed of comings and goings, which we get to know through lived experience (life-paths) rather than static, exiled viewpoints. As emphasised throughout, this view of the world has the benefit of a focus on formative processes, though for both Gibson (1979) and Ingold (2008a) not the human or social, but the full ecological perspective is included.

As we come to know the furnished world in our imagination we recognise how it affords our essential needs and is ready for our survival. That means that if we were to encounter such a world it would be *inhabitable*, because of the intelligibility of the affordances in its physical properties providing opportunities to survive (see **Table 3.1** below). Comparing this understanding to geographer Appleton's (1975) evolutionary theory for the aesthetic appreciation of landscape paintings, there appears to be further grounds for the importance of landscapes to afford inhabitation. Appleton's (1975) prospect-refuge theory focuses on the appreciation of the means for survival and opportunities for protective shelter offered by the landscape shown[20]. Before any human traces and transformation in the world, primordial space would probably have revealed its affordances to our ancient ancestors in this way. Through the experience of 'life in the open world' (Ingold 2008a) we started using caves as dwellings and gathered fruits of the land for subsistence (i.e. acting upon its furnishings). In other words, before impressing our presence on the spatial world, a furnished world already offers opportunities for inhabitation without modification.

In sharp and significant contrast to empty space, the (would be) process of emplaced inhabitation of the primordial space thus includes all perceptible and experiential physical properties for us to engage in interaction with and recognise differences between, through the textures, surfaces, substances, and spatial distinctions (see Gibson 1979; Ingold 2008a). Our experiential knowledge will be appropriated in

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[20] Appleton's (1975) landscape analysis does include human elements, such as a house, placed in the landscape, which often become a focal point for the scene. In his evolutionary view this is due to the refuge they offer.

spatial conceptions, as our ability to perceive the differences in the physical properties of the world and experience their affordances contextually (i.e. making things discrete and giving shape to them within surroundings) is retained. It is in this way that this reasoning goes far beyond the visual perception of Gibson (1979) and the aesthetic theory of Appleton (1975). Primordial space thus is definitely not empty as a 'would be' inhabitable environment. The experience of 'emptiness' should be retained for experimental psychology where voids and the absence of extrasomatic matter could potentially be tested. In our everyday encounters with the world we inhabit, it is through experiencing the spatial world as indistinct (undifferentiated) or equalitarian that we encounter the idea of emptiness.[21]

Equalitarian space

Equalitarian is used as the qualitative description of the experience of the spatial world as continuously indistinctive by repetitions of the same. Equalitarian space is therefore instinctively related to empty space in the sense that repetitions of the same occur to our entire perceptive horizon (technically emptiness is incapable of letting anything occur including things being equal, which is necessarily also indistinct). In idealised form equalitarian space is essentially a situation of continuous binary difference delimiting equal things which repeats itself in a constant rhythm. Concretising equalitarian space, for example as could occur in the primordial spatial world, its scene of features would appear to us as a sensory limitless stretch of repeated equal things. True or ideal equalitarian space is as abstract as empty space and therefore unlikely to exist (cf. Gibson's (1979) open environment). One could, however, imagine concretised examples (think of virtual reality) that come close using the commonsensical boundary of the horizon.

Taking after the image conjured by Ingold (2008a) and Gibson (1979) one could picture oneself being on a sandy plain, a level surface of sand that stretches as far as the eye can see, under smoothly overcast sky. Such a space does not inhibit life and interaction per se, but neither does it *ab initio* offer features that characteristically afford inhabitation. We can only identify all that occurs to us as an equal binary distinction: an endless body of sand and an endless stretch of sky. This would make us uncomfortably perplexed. It may appear to us as simple, but such a world would be beyond comprehension because we cannot distinguish anything in it. We would be in space but

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[21] The Euclidian or geometric space of *spatial science* replicates this emptiness in a particular way.

could not relate our location to anything. Complicating this example the surface may have relief: repetitive sandy hills and slopes. Now we can distinguish the delimitation of one hill from another through perception and experience of the landscape. However, such an endless equal repetition of similar hills will still pose the same limitations as before. Establishing a location and orientation would be hard if not impossible. A further example of this is a dense pine forest. Despite the opportunities offered by trees, the repetitive environment would remain largely unintelligible and in this case strictly limiting our horizon. All trees would be similar and we would be confused by the continuous binary difference. Even in a humanly constructed environment something alike might occur. Imagine for example endless stretches of similar agricultural fields or an urban environment filling our field of vision with uniform blocks of flats. Despite embodying a binary distinction, equalitarian space is therefore virtually *unintelligible* (see **Table 3.1** below).

In the concrete world we encounter and inhabit, monotonous binary heterogeneous landscapes instilling in us a perceptive condition of emptiness are usually delimited and temporary occurrences. As we have come to know the world our expectation is that by using our own physical capacity and command of our body, moving in any direction we will eventually reach differences from the current environment. Nonetheless, people getting hopelessly lost in a forest, the famous fairy tale of *Hansel and Gretel* a case in point, illustrate the perceptive and intellectual gravity of when such situations occur. It is easily forgotten in the abstract world, and then remembered in the concrete world, how the existence and movement of celestial bodies have been old friends to navigation. These aspects are features in the nature of a concrete primordial world, that is, as it would occur to us through lived experience when we start inhabiting it. Since we not only occupy space (as in time-geography) but inhabit the world (see Ingold 2008a) our human condition and capacities, emplaced perception and interaction, will allow us to get to know ‘primordial space’ in all its complexity. The added diversity in differentiation composing complexity in the concrete world offers the opportunities for inhabitation not just on a physical level, but by making it intelligible.

Yet, as the above suggests, when we are emplaced in equalitarian space we would not be completely helpless. When moving from the abstract into a concrete state of the world (**Table 3.1** recapitulates the relation between the stages of the spatial world), we have the ability to interact and incur change in our position and situation as well as the environment. The concrete world does not inhibit our being there and physical interaction with the world, as is the case with the completely abstract constructs of primordial and empty space. When we start inhabiting equalitarian space or are emplaced in the processes of the primordial world, we start to exploit its habitability either as already present or as may become available to us by modification through interaction. *Modification of the physical properties of the environment we inhabit can improve its intelligibility and habitability*. Upon closer engagement with the environment through interaction the limitations (in extent or detail) and characteristics (such as distance) of equalitarian space would typically be revealed. It is through such lived experience that (unique) physical properties reveal their affordances for modification through which they become more intelligible (regardless of the presence of other people) in cases where the concrete world did not itself extrasomatically offer enough differentiation.

Spatial differentiation	**Conceptual nature**	**Intellectual character**
Empty space	Abstract	Unintelligible
Primordial space	Abstract	Inhabitable
Equalitarian space	Abstract/concrete	Unintelligible
Marked space	Concrete	Made intelligible
Filled space	Concrete	Made habitable

Table 3.1: The conceptualisation of the differentiation of being in the spatial world

Marked Space

Being emplaced in the concrete world we immediately (involuntarily) and deliberately interact with our environment, which usually leaves physical traces of our presence and activities in the properties and processes already in place. Marked space entails the modifying effects of our emplaced lived experience of space, including those modifications on extant properties that enhance or improve our inhabitation. When confronted with the perception of emptiness we may thus use our abilities to make (permanent) changes to, i.e. mark, the physical properties of which this space consists for future reference. This introduces an additional or enhanced differentiation into the environment, which improves the intelligibility and in this way the process of inhabitation (through purposeful interaction). *Hansel and Gretel* understood this principle when they decided to leave pebbles on their tracks through the woods. However, when at last these could not be gathered they used bread crumbs instead, but this was not a lasting physical modification, leaving them at a loose (unintelligible) end once more upon return.[22] So, marked space is determined by the introduction of further lasting distinctions to the physical properties and their contexts of the spatial world, like carvings in tree barks or flattening earth and cobbles into paths. The differentiations created render the unintelligible space intelligible by making our previous presence and engagement with its properties perceptible (see **Table 3.1**).

Modifying the physical properties of our environment has a marking effect on the processes of formation (see Ingold 2008a on fluxes of binding and unbinding[23]) that are already ongoing in the world we encounter. In various ways marked space is only a transitional concept. Marking implies that we deliberately modify or enhance the physical distinctions already there or leave traces on surfaces involuntarily. Marked space therefore does not see the full human construction of distinctions. It does not yet pose a full transformation of physical properties to create and subdivide space by design. Nonetheless, intellectually we can connect the dots of the processes of human interaction when we encounter its marks. For example, the traces left by a camping ground we would conceive as a continuous area of past human activity. On the basis of scattered markings we may subjectively project dividing distinctions in space following from, and guiding interactions in, that locus. In this transitional sense marked space conveys only the tenets of a process by which we 'fill' space previously unaffected by human presence (cf. Kropf's (1993) unbuilt environment).

Through the emplaced lived experience of inhabiting the landscape we introduce traces of our presence as we come to know our environment and start recognising the marks of human presence we encounter. Our experiential knowledge of inhabiting the world in this way causes its improved intelligibility. Without the perceptive and experiential understanding of the differentiation between distinct features of the spatial

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[22] In the sense of Appleton's (1975) prospect-refuge theory they also understood perfectly well the potential refuge offered by the humanly constructed cottage they encountered. The risk they found themselves in subsequently was due to social factors and not the physical properties of the space they inhabited.

[23] Seeing the world in fluxes of binding and unbinding may be a very accurate representation of reality. In a way this view rekindles the famous philosophical aphorism *panta rhei* (everything flows) and its associated insights. However, the resultant meshwork disallows the identification of things as discrete objects and therefore hampers any form of empirical research, whilst here the empirical reality of inhabitation seems largely dependent on human recognition and acceptance of occurring things as distinct. In Chapter 4 this view of the world contrasts with, and thus questions, the more rigid physical nature of *bona fide* boundaries (see Smith & Varzi 1997, 2000; Smith 2001), which are instrumental to the empirical data conceptualisation. It can be conceded here that distinctions are deceptively discrete as they always retain a relation to their outside (see the section on autopoietic systems below) as a constitutive contrast, but it would be counterproductive to only see zones of intermingling and mixed entanglement at the interfaces between things (*sensu* Ingold 2008a).

world, the combination of extant properties and introduced markings, it would be doubtful if human beings could function in it. Differentiation is as complex and diverse as the properties affording the sensory perception, intelligible recognition, and experiential knowledge of cause and effect through which interactional methods can modify. All conceptual constructs that become anchored in our knowledge of distinctions that we encounter and learn about, originate in perception and experience. In this way emplaced lived experience builds up (or constitutes) a stock of knowledge (see Schütz 1967), founded upon and thus consisting of distinct (differentiated) elements of things (or constituents of entities) that occur on our life-paths. Appreciating and understanding inhabitation of our environment in this way is a continuous subjective self-referential process, notwithstanding that also without our presence the world is not a static place, but in continuous formation. Thus from an exclusively human perspective (rather than ecological) I concur with Ingold’s (2008a) assertion that we introduce human processes into the world by living and acting (participating) in that spatial formation (‘open world’). One stage further: the process of inhabitation goes beyond making intelligible, to a true manipulation of the environment by introducing differentiation that delimits discrete spatial objects or subdivisions to inhabit.

Filled Space

Filled space refers to a spatial world of our own making. This no longer is confined to marking space to make it more intelligible and thus ready for inhabitation, but comprehends a complete process of *transformation* in which space becomes designed and subdivided according to the effects of our interactions on physical properties for the purpose of inhabiting it. In other words, filled space is the outcome of making space habitable (see also **Table 3.1** for context). As such it appears as merely an extension of (transitional) marked space. Not only intellectually can we now conceive of subdivisions in activity areas, but there is also an empirical reality of actually constructed subdivisions. While marked space results from the modification of extant physical properties of the environment, to get filled space human interaction contiguously contains and transforms its physical properties. This either literally is an extension of previously marked space or, for the place or contiguous locus (cf. **Chapter 1**’s definition of the city), a new process of inhabitation.

One could argue that on the basis of containment or circumscribing areas spatially, the entire world has now been filled (cf. Soja’s idea that most of the landscape is urbanised (Blake 2002)), but this is not the place to discuss the overall extent of the effects of human presence. It suffices to understand that there are still vast regions and scattered patches of the world in which physical properties are not fully or notably determined by human action (e.g. the aforementioned natural reserves). In filled space the spatial world is divided in partitions, including those containing ‘primordial residuals’ that have been created by efforts of physical transformation or building. In essence filled space conceptualises an inhabited environment become a built environment: an appropriated, ultimately transient world made for inhabitation (cf. Rose 2012).

In a built environment marking actions are replaced by building actions which *transform* space. According to architect Van der Laan (1983) the creation of architectonic structures is man’s attempt to make space habitable (which presupposes the prerequisite of the intelligibility of differentiations created). Therefore it is not surprising the human structures in the landscape (e.g. houses) are often focal points for our aesthetic appreciation in prospect-refuge theory (Appleton 1975, see **Note 20**). As we have seen, the spatial world is already inhabitable in various degrees without transformative acts, but building not only improves intelligibility for those who encounter the result, it itself creates further spatial properties that readily afford inhabitation. It makes the inhabitability of the environment we are emplaced in by introducing novel humanly constructed entities with their own differentiating characteristics. In this way the spatial world becomes entirely invested with human lived experience and affords familiarity. We physically construct the distinctions that previously existed as concepts in our mind, either projected from earlier experiential knowledge or linking-up markings following associated ideas, to form roughly correspondent emergent empirical entities introduced through transforming acts of building.

The built environment consequentially consists of physically constructed boundaries. These distinguish between one space and another by a division of extended markings (e.g. from posts to fences) or transformations (e.g. earthen embankments). We create solids and voids, insides and outsides, by building spatial structures (see Van der Laan (1983) and Bollnow (1961) for a more specifically architectonic treatise of this process). Despite the binding and unbinding of the fluxes of the world (Ingold 2008a), these physical boundaries seemingly introduce uniform spatial concepts on both sides of the boundary.[24]

Despite the drastic physical changes incurred, the building of space is a process of the world in formation. Although many physical constructions will endure for long periods of time, many will disappear or transform at later stages through environmental of human processes. Importantly, filled space immediately becomes part of lived experience and all the characteristics of perception, appreciation, affordance, understanding, modification and transformation apply to it. Therefore all the humanly induced spatial configurations we experience are ephemeral consolidated stages of the built environment.[25] Boundaries, either conceptual (recognised differentiations) or materialised through physical construction (**Chapter 2** on 'the material'), are themselves emergent realities, continuously reappropriated upon encounter. Part of the relative persistence of the composition of filled space may be accounted for by its physical affordances, but it is likely that in the actual world this is also the result of their relationship to social formation (e.g. material, mnemonic, emotional, and cultural investments). This resonates with readings of Giddens' (1984) routines for consolidation and cf. De Certeau's (1988) resistance in everyday practice as catalyst for change. After all, in the modern day world we cling to built heritage and often contest physical changes made to the places we live in, while at the same time we may lobby for desired improvements to our material environment.

In its most elaborate form filled space, seen as a built environment, accommodates the entire perceptive experience (horizon) and encompasses the full extents of human daily lives as recurring parts of our life-paths (cf. Pred 1977, 1984, 1986 on the microgeographies of daily life). Such intensity of living in a world filled with humanly constructed spatial subdivisions most likely resembles life in an urban environment (cf. **Chapter 1**). There it is possible that all necessary activities and interactions to sustain

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[24] Intellectually the understanding of the space on the other side may differ depending on which side of the boundary one is located (see Chapter 5 on formulating an ontology). Experiential and temporal spatial gradients may also occur as the world is in constant formation and depending on location in relation to the boundary. Although the contextual and physical properties of each boundary may vary, the division of one side to the other is necessarily always binary.

[25] In Vis (2009) I have argued that if stratigraphic layers of archaeological remains contain sufficient detail on the built environment layout, we may study them as consolidated stages of a developing built environment in one location. The processes operating in the previous stage are constitutive of the consolidation of the next stage, the next stage always necessarily including a reaction to the empirical reality of what was there before. As long as inhabitation of that location is uninterrupted these formative processes are ongoing.

the requirements of daily life take place within the confines of contiguously filled space. However, this consideration already goes beyond human *being* in the spatial world. A single human being in the spatial world is unlikely to succeed in creating and surviving[26] in a world exclusively of his own making rather than acting upon the furnishings of a concrete inhabitable world of extant physical properties. In the concrete world we do not inhabit the spatial world alone in isolation from others. This perspective has only been installed here as a heuristic device. Instead, we inhabit a world with others, a world that is quintessentially social.

Human being in the social world

Individual human being

A true beginning of human-being-in-the-social-world, which reflects grand theories (cf. Ellen 2010) of the formation of society, begins with accepting the same human conditions and capacities as preceded the discussion of human-being-in-the-spatial-world. In summary, as members of the same species we can understand the position and situation of others to an extent self-referentially (empathetically intersubjective). We know the implications of our physical and temporal being and our sensory abilities to perceive and experience with our bodily functioning. We have emotion to appraise our states of mind, and we have cognition which enables us to think. Through the command of our body we can perform actions and the space our bodies occupy makes action necessarily spatial too. Being alone in the social world we occupy a unique (exclusive) time-space position on our life-path (cf. time-geography, see also Pred 1984, 1986) and we come to know ourselves and our environment (*sensu* Schütz 1967), assembling a personal experiential biography. As we come to understand ourselves within the world we become naturally prepared for encounters with others, who we presume to be conditioned like us (cf. humanistic geography, Tuan 1976, 1979).

The social world presupposes the co-presence of human beings, either concerning direct or indirect encounter with their presence. Following the discussion on ‘the social’ as an entity concept (see **Chapter 2**), here the discussion will remain on the rudimentary level of any processes of interaction that require more than one person. Sociology as the study of society has repeatedly shown that unravelling the social and

[26] The survival and procreation of the human species has been an evolutionary success thanks to social processes and cohabitation. Isolated cases of individual survival, the famous examples of the *enfants sauvages* (feral children), are extremely rare and often questionable.

societal world within which human beings live is a complicated subject (Giddens' (1984) seminal work is but one example) and here no attempt will be made to present a fully detailed grand theory of society or conceptualisation of specific societal types and phenomena. Instead this concise presentation of concepts forms part of the framework of conditional statements for inhabiting the world viewed from a social perspective.

Encounter

If we understand co-presence to mean the existence of more than one person and perceiving and conceiving of the existence of others, encounter necessarily entails interactional engagement. Since time-geography has demonstrated space cannot be occupied twice, encounter necessarily requires two (or more) people to have their own position and any distance between these. Whether it is seeing from afar, e.g. nodding to a stranger in the street, or intimate closeness, e.g. embracing a friend coming to visit, we occupy distinct positions in space and have arrived there living through necessarily distinct emplaced lived experience. Beyond immediate sensory perception, our means of communication (acknowledgement or signaling and informative) are initially limited to our corporal and oral/verbal abilities. In performing acts to engage (interact with) the other what we truly mean or intend becomes translated, first, into what we are able to send and secondly in how it is received. The latter entails a translation through the receiver's unique biographical position and situation. Therefore, we necessarily relate the encounter and any associated communication to ourselves, which comprises the self-referential condition of our understanding. Even linguistic structures emerging from the development of verbal communication and deceptively designed to give the impression of neutrality and objectivity cannot overcome these subjective limitations, causing inaccuracies and misunderstandings (vs. language pragmatics, see Zierhofer 2002).

Self-referential understanding also allows us to understand the presence of others by recognising and interpreting the traces and transformations they left behind (e.g. a house or camping ground). Encounter then relies on indirect co-presence: someone else occupying that space before. In this way the dynamics of social relations can be extended into situations where it is not necessary to have two people present within the confines of their respective mutual perceptive horizons.[27]

As briefly referred to in the above, encounters do not only necessarily involve the space we occupy, they also imply the distances between those spatial occupations. When we encounter we set and respect (establish) a certain distance to each other appropriate for our intersubjectively understood relation and activity. The spontaneous differences are already expressed in the exemplified communicative acts of nodding to a stranger and embracing a friend. It was anthropologist Edward Hall (1959, 1968) who, inspired by biological ethology, devised a field of a study of the interpersonal distances that are respected in social interactions through which social relations are established. He attempted to uncover the cultural differences in this 'distance setting' under the field of study he called proxemics.[28] The personal territories (i.e. personal space) that emerge from the process of distance setting are the first voluntary spatial differentiations in the social world. Here it suffices to take into account that people will create interpersonal distances in every interpersonal contact that occurs and appropriate the distance to each activity (interaction) that occurs. In other words, human beings amongst each other negotiate territories, or comfort zones, for each activity they engage in. This is the first stage in the organisation of the social world spatially, which depends on the relations emerging from encounters.

Projects and institutions

The theoretical framework informing Pred's (1981, 1984, 1986) work on the becoming of place and the micro-geographies of everyday life critically moves along the lines set out by Giddens and Foucault on societal organisation and power. Pred informs us that along their life-paths people set out to reach goals and perform activities which are conceptually framed as 'projects' (cf. Giddens 1984). Pred's time-geographical adaptation demonstrates how social relations intersect our life-paths and

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[27] Incidentally, accepting this possibility is a necessity to conduct archaeology, where being researchers our encounters with our human subjects takes place through material remains only (cf. Fletcher 2004: archaeology assumes the material pattern of behaviour and its recognition outside actual knowledge of the builders).

[28] Anthropological proxemics is not to be confused with the geographical field of proximics introduced as part of the regional geography of Granö (1997), which is not social but sensory. "The proximity is that part of the environment that is perceivable with all the senses and is situated between the observer and the landscape." (Granö 1997: 108) Geographical proximics then studies the types of proximities of the earth's surface and identifies uniform areas and zones.

how projects are formed along the life-path operating in time-space convergences. In projects arrays of social relationships may converge to achieve a goal all project participants individually subscribe to. As an aside, though, one should acknowledge situations in which individuals become part of projects without intention to subscribe to what is intended by the goal.

Projects can either be undertaken individually, as if interacting alone within the spatial world, or institutionally (in a group). The latter can be described as an individual's participation in projects that involve other people's participation. In everyday practice it is the constant intersection of individual life-paths and institutional projects that dialectically creates social structure (the emergence of open systems). This dialectic both consolidates and negotiates transformations of our relationships with others. At the same time the emergence of social values, biography formation and the transformation of nature occurs (see Pred 1986, **Fig. 3.1**), the latter process encompassing at once marked and filled space.

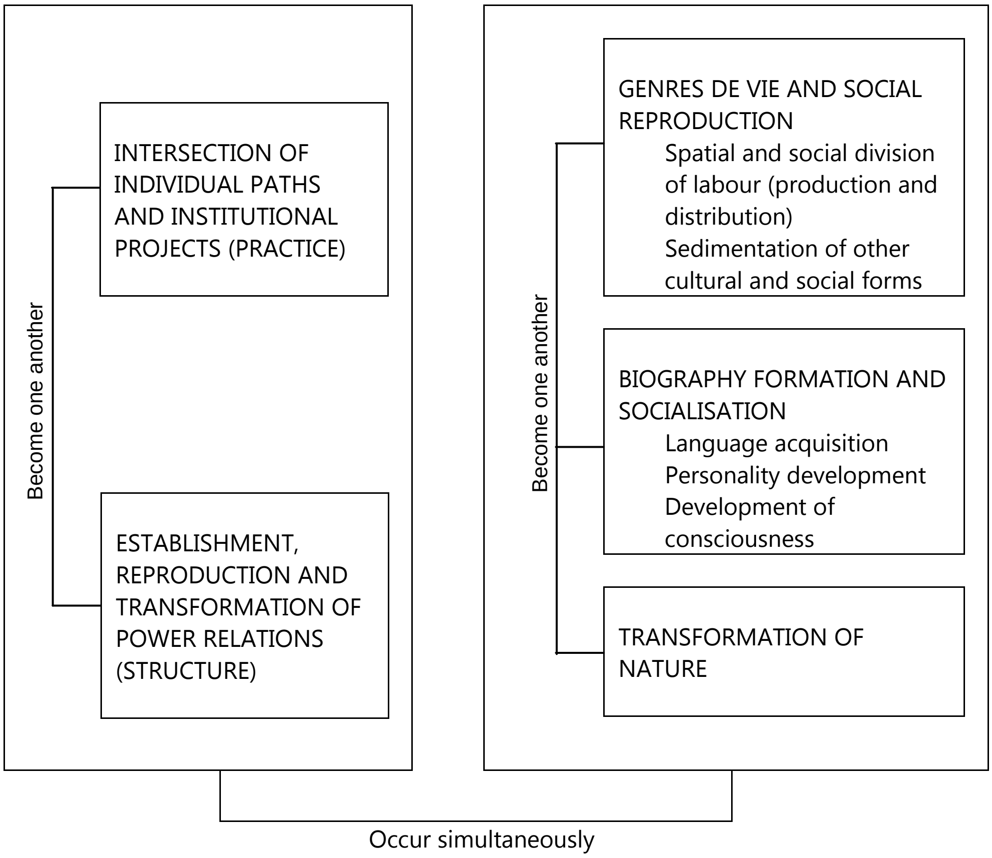

Fig. 3.1: Pred's historically contingent processes of becoming
These processes form the core of his theory of place formation (reproduced from Pred 1986: 11).

Given the local, temporal, and personal constraints on these occurrences along time-geographical life-paths and their constant intersections in time-space specific social situations, the foundation is laid for the emergence of spatially distinct autopoietic social systems proposed by Koch (2005). These ‘auto self-creating’ systems are components for society in the inhabited social world, but themselves emergent entities as their causal power (to achieve goals) is distinct from that of individuals (see **Chapter 2**). The intensive collision of individual biographies (the accumulation of experience and knowledge) that are closely related in time-space in projects that transform and shape space for inhabitation, due to their necessarily emplaced condition dependent on their participants, creates the converging concepts on which a (communal) sense of place and belonging is founded. All these systemic elements are present in Pred’s theory of place as historically contingent process. Together these processes convey the way in which the social world emerges in inhabiting the spatial world. As the social relations of projects cannot be extracted from their spatiality, the two are intrinsically linked as the socio-spatial world unfolding as a continuous process of becoming.

Autopoietic socio-spatial systems

As implied in the continuous process of becoming of the socio-spatial world, it is now clear from the conceptual sequences (human *being* in the social and spatial world) discussed so far that the conditioning of interaction with spatial and social properties is in both cases constitutive of this process. The constitutive presence of the properties of space in the social world creates the basis for a view on society’s spatiality. The constitutive components of society as an emergent entity (cf. **Chapter 2**) consist of causal powers of the humanly conditioned generative socio-spatial systems, which are themselves in constant formation when performed towards the participatory aims. Socio-spatial systems have been theorised to be autopoietic (auto self-creative) (see Koch (2005) and Arnoldi (2001) for this view of systemic society). This means they are understood to simultaneously constitute themselves through differentiation from within and from without, i.e. on the inside towards the outside. As Koch (2005) asserts, all elements remain independent (autonomous) and mutually constitutive. That is, the social construction of spatiality and the spatial construction of sociality are mutually dependent. Being part of social systems produces understandings of the spatial properties engaged in the system through a process of differentiating those properties in their systemic environment. That means they make the resultant modified and constructed environment socio-spatially intelligible in terms of social conceptions.

In this way social systems invest the environment within which they occur with meaning, which is likely to be more interpretable depending on the extent of convergence of proximity in participation patterns along individuals' life-paths. At the same time the constitution of meaning through transformations of properties caused by autopoietic systemic differentiation is significant to all human inhabitants of the world. This is not just differentiation (phenomenologically simply: something is not something else), i.e. meaning and significance captured in oppositions, but contains its own outside. Whenever through systemic performance a distinction is made or reconfirmed, the nature of the system itself is being constituted.

> "Through a structural coupling (a history of recurrent interaction leading to structural congruence) of two or more systems [in the environment], certain features of the environment are constitutive for the autopoietic process [...]. This makes the identification of the boundaries of an autopoietic system problematic, because some parts of the environment are internal to the system, i.e. the system is partially extended into the environment." (Vis 2009: 114)[29]

Systems are also temporal as they cease to exist when the actions that constitute the system are not performed (cf. Koch 2005) (many systems can be transient and transitional in scale and performance). It could be said that systems have constitutive (socio-spatial) environments, while actions have constitutive (social and affording) contexts (cf. Bruun & Langlais 2003). This means that existing spatial properties form constitutive environments, while individual participants' biographies of emplaced lived experience form a social context for the actions that let systems emerge (cf. critical realist causality and emergence, **Chapter 2**).

Koch (2005) specifically ties the idea of autopoietic social systems (see Arnoldi 2001) to the delimited spaces they occupy or inhabit. In addition, I emphasise that through the transformative interactions constituting them, social systems create the spaces both through and for their performance. The social-systemically occupied spaces (see **Chapter 4** on subdivision) thus form socio-spatial systems with a boundary to their outside, dependent for their definition on their constitutive environment and for their (temporal) existence on the (contextual) human actions that operate them. So, it

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[29] These ideas are mainly derived from Bruun & Langlais (2003).

becomes apparent these are ongoing and interconnected constitutive processes in constant social and environmental flux dependent on human interaction in space leading to the emergence of society. In this regard the social world as it occurs within the spatial world is just as much a process of binding and unbinding elements, as the ecological view expressed by Ingold (2008a).

The emergent socio-spatial systems are not confined to any scale. Indeed society as an emergent entity is probably best conveyed as a causally specific ultimately complex version of a project based institutional system and the process of globalisation as an emergent global society. This is how the full breadth of 'the social' (**Chapter 2**) inhabits the world. Because the physical properties of the environment that materialised through transformative acts are now structurally coupled to the process of inhabitation, in which differentiating autopoietic socio-spatial systems occupy from the inside what is distinct towards the outside in contiguous interrelations, the physically and conceptually constructed interfaces (boundaries) are linked to the subdivisions forming filled space, i.e. the built environment.

Inhabited built environment

On the basis of what has been argued in the sequence of human-being-in-the-social-world the built environment can now be 'populated'. That is, we can correct the view of filled space in which other people were conspicuously missing. Quickly revisiting that view, without any humans inhabiting it, the spatial properties of systems composing the built environment receive their *congruency* as an architectural system. Koch (2005) distinguishes the spatial system, consisting of geometry, topology, and fuzziness, from the associated architectural system, consisting of the materiality (structure) without which it could not be built. This in turn is separated from the social system, a perspective that resembles the pre-emptive elements of territory, place, network scales, and network in the topological discussion of socio-spatial relations by Jessop et al. (2008). Here no such pre-emptive categories are distinguished if they do not directly emerge from these fundamentally human conditional statements. Hence it is through the physical properties of the material (*sensu* Wallace 2011) of the architectural system that the spatial system is characterised, meaning that on the same basis of the material as an emergent entity, its understanding cannot be separated from the social realm. Nonetheless, the constitutive components at play in any systemic relation will remain distinguishable, and their causality in isolation may differ from the causal power of the system. This reasoning resonates well with a previous conclusion I reached:

> "[T]he significance of [built] space is both spatially relational and necessarily material. Relational entails the extension of the borders of spatial entities to the relational constitutive dimension (cf. constitutive environments), while material simply refers to the fact that all [spatial] entities [...] are irreducible to a mental state. [...] Relations are not only social, they are also spatial, because we live and act in a materially heterogeneous world. This enforces that neither objects, nor spaces and communities can be reduced to something one-dimensional." (Vis 2009: 116-117)[30]

Although the architectural system includes the characteristics of the internal structure of the residing socio-spatial system, in this research the interest lies more narrowly with the interfaces of differentiation between socio-spatial systems than their internal dynamics. This refers to the coarser nature of enduring empirical data that can be expected over time to be available on the built environment. This readily pertains to what Mekking (2009; see **Chapter 1**) referred to as the walls that divide between an inclusive 'us' and an exclusive 'them'. Through physically transformative acts, these interfaces have become material, which includes their continued occupation by socio-spatial systems. They form the empirical built boundaries (**Chapter 4**) of which the built environment is composed. An understanding of the significance of the built environment to societal inhabitation and development depends on these boundaries.

The socio-spatial complex that is the inhabited built environment composed of built boundaries is formed in the ongoing differentiating (binding and unbinding) performances of socio-spatial systems. It posits an immediate human and social reality characterised by incorporated physical affordances. As soon as a spatial configuration is introduced, e.g. construction of a fence around a green or a new residential block, it becomes part of the constitutive environment and experiential context of the ongoing systems occupying the contiguous locus. This in turn means that the material features that result from the transformative operation of these systems should be understood against that theoretical background.

Despite the seemingly static wording of 'empirical built boundaries', these differentiations, as dictated by seeing the inhabitation of the socio-spatial world as a

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[30] Note that in this quote 'material' is used in the sense of physical substance, and not 'the material' as an emergent entity used in this research.

process of becoming, are in constant formation and therefore fluctuate as the system is performed by its participants. Once transformations are introduced, these necessarily occur in relation to physical distinctions created as a part of system emergence. This physical difference tends to be a more persistent and enduring marker than the rationale and intentions of the original interactions that differentiated. Archaeological 'material remains' confront us with the materialised approximations of human and social differentiation, which appear to us as fixed, but which we can self-referentially infer socio-spatially. The intellectual understanding of transient, transitional and temporal interaction-dependent socio-spatial systems is necessary for interpreting the inhabited built environment, which as a material (rather than merely physical and empirical) phenomenon is necessarily linked to the social. This does not withstand developing a geometric and topological framework in support of configurations external to the social perspective insofar as they are expressive of the affording properties in the light of inhabitation as an ongoing interaction process.

This theoretical framework of the constitution of the inhabited built environment forms a rigorous specification and elaboration of an interpretive spatial approach I have previously called the 'social positioning of spatialities' (Vis 2009). The fixity of the built boundaries making up the configurative complex of the built environment we observe thus is not equal to how we understand their constant constitution in the inhabitation process through time. They are merely physical approximations of the outcomes intended by or emergent from transformative interactions and occur as affording social realities in subsequent encounters.

Throughout it has become apparent that it is a necessity of inhabiting the world that we recognise differences through emplaced lived experience in that world. When we eventually manipulate the physical properties of our environment we create entities from the inside towards the outside on a flexible scale. Human-being-in-the-social-world, as such, is constitutively significant on an all-encompassing fluid scale of time and space which stabilises depending on its action specific context. Therefore, the inhabited built environment complex we perceive of as an object of study entails composite entities and aggregates[31] affording and resulting from interaction patterns and

[31] Note that as the outcome of interactions can never be foreseen, emergent entities and aggregates are increasingly unlikely to be fully intentional on an incremental (socio-spatial) scale, in the sense of realising a single human being's envisioned improvement on position and situation. This applies to both top-down administrative decisions and bottom-up construction, as the capacity of a single human being to transform the world is limited, which is after all why filled space is unlikely to exist in the absence of others.

experiential familiarity. Their relative endurance is expressive of the extent of adherence to their occurrence as it is inevitable that people react to boundaries once they exist. The entities' internal composition is necessarily part of the case specific intrinsic logic of socio-spatial significance of any urban locus.

Boundaries

In the framework above constituting the inhabited built environment, we are left with the paramount significance of *boundaries as the result of the intellectual and experiential requirements of differentiation allowing the process of inhabitation* of the world to take place. We know the built environment as an empirically accessible object of study and it has become established that empirically built boundaries compose that built environment as outcomes of transformative differentiating interactions. It is therefore argued that a study of boundaries conceptualised in accordance with this theoretical framework is indispensable for generating understandings of the socio-spatial significance their presence poses to inhabitation of the world (in terms of how they afford and qualify interaction within that world). Moreover, it could be argued, following the working definition of the city in **Chapter 1**, that only in urban settings is the transformation of the environment so complete as to fill the perceptive horizon and envelop the necessities of ongoing daily life in a contiguous locus. Logically the best understanding of society on the basis of a built environment can be achieved when transformation is most elaborate. It is therefore expected that in urban settings a study of boundaries as an analytical category would be most productive. *Urban form is then seen as a configuration of boundaries*. By means of boundaries it is hoped that Griffiths & Quick (2005) theoretical appeal to study spatial configurations following the premise of human beings situated in a holistic physical and social environment can be further concretised.

In a recent discussion on the study of territory as a topological category Elden (2011: 306) argues that “there is definitely agreement that the approach to be taken should emerge from the questions asked, rather than being defined in advance.” As a consequence the framework here sets the agenda for conceptualising our information source (spatial data on the built environment) so as “to allow the object of analysis [here boundaries] to dictate the way in.” (Elden 2011: 306) The following chapter will therefore discuss how a thorough understanding of boundaries guides us into a way to engage with empirical data.

CHAPTER 4 – THEORISING MATERIAL BOUNDARIES, UNDERSTANDING SPATIAL DATA

Introduction

The theoretical framework presented in **Chapter 3** has clarified how differentiation is a prerequisite for inhabiting the world. It has been established that in the process of inhabitation we have the capacity to manipulate and introduce differentiations into our world, which depend on transformative acts. The so constructed boundaries subdivide the world into emergent entities. It is by the intentional acts of creating boundaries that the concrete world we inhabit becomes 'filled' as a humanly constructed built environment for the purpose of our inhabitation. These boundaries follow from conceptions of our experiential understanding of the world in their respective and unforeseeable ongoing environmental and social contexts. The material nature of the inhabited built environment consists of a composed configurative complex of boundaries affecting and affording our experience, interaction opportunities, and appropriation for inhabitation. The differentiating boundaries are inextricably social and spatial as humanly constructed material components, from which they derive their operative causal powers and attain their significance in interaction.

The further merit of (material) boundaries as a concept to think with is the subject of the current chapter. Thinking through boundary theory and concepts eventually allows us to distill spatial data, demanding a clear understanding of what is truly conveyed by them and how mappings are created from this information. It is only from this refined perspective on the translation of empirical reality into spatial data that socio-spatial concepts can be formulated (**Chapter 5**) which simultaneously carry ideational meaning (in accordance with **Chapter 3**) and are empirically identifiable.

Theorising boundaries

In order to better appreciate the information which is unlocked by regarding the inhabited built environment as composed of boundaries giving rise to entities, a closer look at boundaries as a concept and within this context is needed. Differentiation demonstrates that we come to know any entity by its distinctions to its outside, i.e. at the boundary, and when we create conceptions of the world around us we start by recognising the binary distinction that something is not something else. This has led to the suggestion that boundaries are the basis for knowledge in general (see Jones 2009), and a knowledge based on differentiation sits comfortably with constitutive phenomenology (Schütz 1967). The logical implication of this is that the socio-spatial significance of the material presence of the built environment in inhabitation should not start with the entities that commonsensically jump out to us (based on our lived immersion in time-space specific socio-cultural contexts), but with the characteristics of the distinctions incorporated in the boundaries that compose it.

In the academic field of boundary studies in human geography, sociology, and philosophy, this is exactly was has been suggested in general: not to study entities, but the boundaries from which they emerge (Abbott 1995; Jones 2009, 2010). Against the background of the discussion of social interaction and relations and the emergence of socio-spatial systems, Abbott's (1995: 860) assessment of entities falls into place: "social entities come into existence when social actors tie social boundaries together in certain ways. Boundaries come first, then entities." How entities become physically distinguished by boundaries is the specific constitutive human and social datum of the inhabited built environment.

It could easily be argued that in the context of the built environment, boundaries are merely built distinctions and divisions, whilst 'boundary' as a term is as protean as it is elusive. Yet, it is exactly this flexibility that makes it suitable in the light of how we have come to constitute the inhabited built environment that has been identified as the object of study in this research. Regarding only the 'built distinction' is unable to capture the full socio-spatial complexity of the differentiation introduced beyond a physical and empirical outcome of interaction. The term 'boundary' is both accurate and can be invested with the empirical and ideational social reality it specifically represents in this context.

In speaking about boundaries, however, it should be noted that imagined or ideational boundaries, what could be called socio-cultural, geo-political or formal and administrative symbolic boundaries as constituents of social categories, have received much attention in sociological (e.g. Lamont & Molnár 2002) and anthropological research (e.g. Pellow 1996). In historically and socio-culturally contextualised themes, such as power, religion, economics, etc., boundaries have been the object of research in various guises: from very implicit social boundaries and categories in Van Gennep's and Turner's anthropology of rites of passage and symbolism (see Turner 1969; Bell 2009) to more explicit boundaries of organisation, territory, and international borders (e.g. Abbot 1995; Lamont & Molnár 2002; Jessop et al. 2008; Jones 2009). Where built space in particular is concerned, the main strands of influential scholarly thought from socio-cultural, economical, and political perspectives are usefully summarised by Archer (2005).

As argued in **Chapter 1**, the highly interpretive representational analogies or metaphors needed for such perspectives are deemed inappropriate for this research's comparative social scientific aims. Furthermore, in **Chapter 2**, the rudimentary nature in which the social is applied here has been determined. On this basis, here boundaries will not explicitly refer to differences in class, nation, kin or cultural identity, even though these aspects of social life are also of influence on how the differentiation posited by built boundaries is understood. This is not to deny the existence or importance of these higher level social aspects. As a case in point Lawrence (1996: 33) stated that: “It was commonly at the border between private and collective spaces (by the entrance door or at the windows) that residents engaged in expressive behavior with kith and kin.” This quotation illustrates Lawrence's parallel assertion that boundary thinking is capable of converging many disparate social and cultural research interests. So, despite the subdued implicit presence of these socio-cultural concepts and categories, which often are at the core of boundary research, in the current research context it is acknowledged that they are *inseparable parts* of what is studied socio-spatially. Due to the limitations of the current means, data, and theory, these aspects of boundaries cannot be directly accessed within this comparative research purpose.

The emergent research literature on boundaries is littered with examples of metaphorical representations which seem to take as a presupposition the fundamental empirical and experiential recognition that any feature or component of the world is eventually delimited, at which instance it becomes something else. In the language and philosophical underpinnings of metaphorical, representational, or abstractly analogical and relational approaches to the study of boundaries, borders, barriers, limits, and edges often homage is paid to Deleuze and Guattari. However, their dense ‘geophilosophical’ language of space, speaking of deterritorialisations, lines of flight, and smooth vs. striated space, remains overly ideational (especially Deleuze & Guattari 1987).

While Deleuzo-Guattarian ideas are invested with the vigour of politics and power and are evocative and thought-provoking, within the context of boundaries making up the inhabited built environment a full-blown Deleuzo-Guattarian approach is not deemed appropriate as it remains detached from the physicality of material presence as a vantage point.[32] As established in **Chapter 3**, the foundation of the research interest here is formed by the immediately empirical (experiential) and intelligible nature of our human condition and the process of inhabiting the world with its physical and social properties instead of taking inspiration from ideational and historical contexts. Nonetheless, without highlighting any concrete application or ascribing particular purchase, Deleuzo-Guattarian thought is a useful background for making sense of deconstructing institutionalised and discursive categories. Here, deconstructive notions help to uncover the transformative processes that let spatial entities emerge to constitute a heterogeneous environment in which introduced differentiations evoke a multitude of affective and affording responses.

We can take from this that deconstructive discourse in boundary studies merits our attention. Before boundaries as a constitutive datum can be effectively used as an 'analytical unit' in research, its conceptual basis as an information source should be established. How can we access the information boundaries contain? Jones (2009) argues that the heterogenesis produced by deterritorialisation reveals a socio-spatial complexity that is normally disguised by categorical divisions. In the same way the built environment can be seen to disguise socio-spatial complexity in its fixity and apparent 'container units', i.e. entities like occupiable areas or building categories. However complex urban form in general, as constituted by the features of the built environment (shape, layout, configuration, etc.), may already appear, it is in fact a simplifying empirical approximation resulting from a focused reduction of the intricate negotiation processes which put it there.

Thinking beyond categories

It is readily agreed that much of current research is essentially based on assumed or predetermined categories. Jones (2009) and Abbott (1995) both note that much effort has been invested in establishing categories or entities for research. Jones (2009: 175) argues:

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[32] A discussion of bordering and materiality as is featured in the work of Deleuze and Guattari can be found in Woodward & Jones (2005).

> "[...] there is a tendency [...] to analyze the categories rather than the 'process of "bounding" and "bordering"' of which these categories are the result. [...] [T]he problem is not the categories themselves, but, rather, the way the boundaries around the categories are cognitively understood as closed and fixed even when we know intellectually that they are open and fluid. Consequently [...] the key process is the bounding and delimiting of the categories used to understand the world."

According to Jones this issue emerges from our ingrained mental processes. "[...] we cognitively think of categories as containers, we consequently imagine all categories to be inherently closed, with fixed, stable boundaries between them. Yet, intellectually, we know that these boundaries are almost always fluid and permeable." (Jones 2009: 179) The fluidity, flexibility, and transience of any socio-spatial system (see **Chapter 3**, also Vis 2009), as constitutive of inside coherence incorporating its distinction towards its outside, demonstrates this same insight.

Jones (2009: 179-180) continues his cognitive explanation of categories and the crucial role they play in making sense of the world claiming that, once installed (imposed and learned), categories limit and control our experience of social life, and here could be added the inhabitation of the world. Consequently, he proposes that:

> "[…] geography should re-emphasise its connection with these topics through an analysis of the inchoate process of bounding that delimits the categories that shape daily life and academic work. [...] It is *inchoate* because it occurs over time as the boundary is just beginning to form, is incomplete and is bounding an entity that is lacking structure and organization. [...] [Boundaries are] a *process* because of this ongoing necessity for re-fixing, rewriting and renegotiating the boundaries. [...] Boundaries concomitantly take diversity and organize it and take homogeneity and differentiate it."

Jones takes his cue from Abbott (1995: 857), who notes: "It is wrong to look for boundaries between preexisting social entities. Rather we should start with boundaries and investigate how people create entities by linking those boundaries into units. We should not look for boundaries of things but things of boundaries." Abbott (1995: 868) argues further in support for his processual[33] ontology: "it [does] not really matter what these boundaries were, at first. They began as simple, inchoate differences. They were not boundaries *of* anything."

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[33] The use of the word processual should not be confused with the archaeological paradigm processualism.

In the words of Abbott and Jones we discover some coherence that resonates with the constitutive conditions theorised in **Chapter 3**. Though they choose to focus on boundaries as a phenomenon, taken as the distinctions between eventual categories or entities, we see how their arguments for the emergence of entities from boundaries as a continuous process roughly concur with how human beings modify and transform the physical properties of the environment they inhabit. More specifically, Abbott's 'linking' of boundaries conjures up a close mirror image of marking being extended to subdivide or partition the spatial world into filled space, but also how project participation through the performance of action internally defines systemic entities to their outside. This shines through in its most pronounced form in Jones' (2009: 180) comment on Abbott's 'thingness' of entities: "[thingness] is not pre-given but, rather, is only the result of the contingent process of linking up these locations of difference."

Interestingly, Abbott's (1995) notion about the structural resilience of entities resulting from their defensibility in several dimensions of difference is relatable to the idea of the socio-spatial constitution of autopoietic systems (**Chapter 3**). This inherently combines the dimensions of the human life-path, social, and spatial processes through which the concrete inhabited world becomes invested with differentiations. In the inhabited world boundaries provide intelligibility, habitability, and a sense of (biographical) familiarity[34] through our participation in their continued constitution and development through human interactions with the socio-spatial environment. Their subsequent existence necessarily accommodates the constant processes of binding and unbinding, negotiating the introduced differentiations, as we continue to participate in their constitution. This dimensionally complex combination tentatively explains why ultimately many built (materialised) boundaries are persistent (or resilient, i.e. emergent stability) over time (a key premise for urban morphology, see **Chapter 6**).

The togetherness (cf. Hägerstrand 1976) or relations between built boundaries is readily perceived to connect the distinctions by which we come to know and make sense of the inhabited world as subdivided, i.e. the entities and categories of the inhabited built environment. Even when the performed system originally responsible for the introduction of the differentiation of a built boundary ceased to exist and/or is replaced (i.e. Sayer's (2000) spatial independence and Mekking's (2009) mismatch between use and intended use of a building type), its material presence has continued to

[34] Familiarity with (patterned or aggregating) differentiations is intended to be a very broad concept in which belonging, memory, and even claimed or emotional ownership (supported administratively or arising through personal investment and participation) can all have part.

occur in our socio-spatial environment and as such remains susceptible to modification and participation as a constitutive contextual component in other interactional relations of inhabitation. Only obliteration is a one-off reconfiguring interaction.

In what I have previously called the consolidated stages of the built environment (Vis 2009; cf. Abbott's (1995) lineage of events), boundaries get physically constructed by human beings, i.e. they are built. At that point surfaces of matter or substance receive edges (physical distinctions) that are introduced into the environment, which physically persist as a built (humanly constructed) shape within the continuing processes (fluxes) of the physical environment. This persistence forms a degree of inertia, and it disguises the ongoing fluxes (cf. Ingold 2008a) of the environment and the inchoateness of the formative processes as conveyed by Jones (2009). Even though they are variable according to their conditional nature and their contextual position and situation, the persistence of built boundaries tends to be strong. That is, many past built forms persist into the present and/or have a long lasting effect.

Yet, simultaneously the inhabited built environment is also ephemeral. Socio-spatially the processes of inhabitation might not affect or change each built boundary physically at every event of ongoing development during local residence. In the longer term, however, this consolidation in the inhabitation process is merely a stage, as the ongoing processes may at any time modify and transform both the constitutive environment of the built boundary (which contextually characterises) and the material properties of that boundary as it so far existed. This consolidation process, especially taking into account resistance within the everyday practice of inhabitation (cf. De Certeau 1988) as a catalyst for change, bears some resemblance to Star's (2010) ideational cycle of standardisation (cf. structuring and imposition), residual categories (cf. everyday resistance), and 'boundary objects'. With any physical change or development, boundaries will often be consolidated again in their new situation or shape. Historical and archaeological data on the built environment should therefore be seen as consisting of such an ephemeral stage in ongoing (inchoate) processes.

In contrast, providing some context to the type of deconstructive thinking propagated above, it could commonly be noted that thinking on boundaries is articulated by what could be called the 'scientification' of social research conduct, which favours explanatory law and regularity seeking observation based 'natural' sciences over social and interpretive approaches pursuing exploration and human understanding. Such natural scientific approaches in particular thrive on the concept of categorisation, setting the expectant norm, for without categorisation observations could not be turned into orderable data. Quantification, which is the basis for many kinds of analysis, would not be possible, because it relies on the notion that things are discretely separated, i.e. adhere to static divisions, despite the ongoing processes that can be observed in the natural sciences. Even when we accept a processual view in social sciences, a long-term temporal view will typically make it appear as if phenomena 'suddenly' appear and disappear, in spite of our understanding that they are part of continuous processes. In recent years, fuzzy set theory has been developing quantifying approaches that approximate the recognition that distinctions and boundaries are not discrete and part of continuous processes and complex interrelations[35] (e.g. Fesenmaier et al. 1979; Abed & Kaysi 2003; Tang et al. 2007; Pleho & Avdagic 2008; Yusuf et al. 2010; Kim & Wentz 2011).

Classification in archaeology is most traditionally tied to constructing area specific progressive periodical typologies of artefacts. These typologies tend to be based on dimension, shape, and other exclusive characteristics observable in isolated examples, not relationality (Read 1989; though see Hermon & Niccolucci 2002, for an application of fuzzy logic to improve typological interpretation). Read (1989: 184) argues that automatic classification approaches (cf. objective measured approaches) are still some way off from cohering to the understanding we have of archaeological (cf. human) data for which no solution is yet available.

> "If structuring processes are the beginning point of understanding the data in hand, then the initial goal becomes one of relating structuring process to measurable groups in the data and not the reverse. One might devise a sequence going from general process to material realization, but the difficulty arises that the sequence does not predict the particular form the objects should take. Hence it does not predict what will be appropriate measures, with the possible exception of those such as the tip of the point; that is, measures that are clearly constrained by the tasks for which the objects are to be used. If it is not possible to go from measures made over a collection of objects to classes via numerical methods, and if definition of the taxonomic structure does not lead to prediction of form, then it is necessary to devise a means to provide the missing part of the argument."

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[35] It should be noted that many fuzzy set approaches try to work towards classifications from ambiguous artificially sensed (automatically acquired) data.

Throughout preceding arguments the inchoate process of forming boundaries, or bounding, has become recognised as an operative for inhabitation of the world and the constitution of the inhabited built environment. In concordance with Read's suggestion, one could argue the built environment is used for inhabitation and therefore possibly the 'measures' of it can be predicted. However, as we have seen (see **Chapters 1** and **2**) there is considerably flexibility and independence of social life from the exactitude of spatial form and physical characteristics. Hence, ordering a study of boundaries ontologically can only first depend on a 'typology' of the kind of *operation* they facilitate, which does not predict their precise relational situation nor the shapes and sizes of its occurrence (cf. Fletcher's (2004) interest in material operations; an ontology of types features in **Chapter 5**). The built environment as seen as utilitarian for inhabitation, which we know is necessarily emically salient (see Read 1989) — i.e. meaning that is accommodated in a fuzzy way by socio-spatial significance of material presence — for the inhabitants, is first and foremost relational and processual, but these relations are in part determined by the contextual influence of shapes and sizes by which their occurrence can be measured.

Studying boundaries

"[…] the problem is not the categories themselves, but, rather, the way the boundaries around the categories are cognitively understood as closed and fixed even when we know intellectually that they are open and fluid. Consequently [...] the key process is the bounding and delimiting of the categories used to understand the world." To follow Jones' (2009: 175) argument to emphasise the process of boundaries rather than the resulting categories and to view apparently emergent categories as inchoate is to let qualification of their study precede or even preclude their quantification. Launching a study of built boundaries then "allows a move away from [the boundary paradox] and creates space to contest categorization schemes" (Jones 2009: 185) in the sense of moving away from conflating architectural building types or use prescriptions (see **Chapter 1**) in the built environment. It entails that in studying the built environment we should be identifying — as inchoate relational social positioning in the whole — those elements of it that materialise (or physically approximate) the meeting of different socio-spatial systems and their participants. So far we have been able to conclude that built boundaries are the elements that link up constitutively to form the entities we perceive and are inclined to base investigation on.

It becomes apparent that this proposal is in agreement with Schaffter et al.'s (2010: 260) critique of Jones (2009): "Boundary studies, however broad and theoretical, must [...] remain alert to spatiality and materiality, and not just to processes of construction." Star (2010) also emphasises the process of construction, though her conceptual cycle arguably leaves some space for the persistent existence of versions of her boundary objects. In the boundary approach towards studying the built environment pursued here, social and spatial theoretical constructions are joined with a boundary concept that can actually be observed (as data) and mapped, i.e. built boundaries. This connects to Jones' (2010) argument that non-spatial concepts should not just be left to other (non-geographical) disciplines (vs. Schaffter et al. 2010). The theoretical position of this interdisciplinary research clearly articulates that society and (the physical properties of) space cannot be separated. Dialectically constituted by human beings encountering and interacting with and within the concrete inhabited world, the material presence of these built boundaries becomes part of the experiential and intellectual (knowledgeable) biographies of human beings continuing along their life-paths (this explicitly integrates boundaries in **Chapter 3**'s constitutive framework).

As Jones (2009, 2010) is making good arguments for geography to be specifically concerned with the categorisation of the world on the basis of boundaries, it is quite interesting to see that Granö in 1929 (1997) defined the geographical discipline on the basis of how we construct geographical regions. In the review of Paasi (2002) it transpires that this is clearly related more broadly to how we define categories and interpret them and how they are socially constructed. In this manner Pred's (1984, 1986) work on the historically contingent process of the becoming of place once more proves pivotal to connect the empirical and physical (predominantly referred to as spatial) to social construction and personal biographies in materialisation.

The foregoing theoretical treatise on the processual cogency of boundaries can thus serve as the 'deterritorialisation' of the entities and categories that habitually make up research perspectives on the built environment. Mechanistic concepts were introduced in **Chapter 3** to reveal the processes of the constitution of the built environment. They demonstrated intellectually the socio-spatial complexity of differentiation for inhabitation that constitutive processes represent (which is otherwise at best assumed). Against this elaborate foundational background we are now sufficiently informed to start an analysis of the configuration of the urban built environment on the basis of its constitutive empirical elements: built boundaries. The task at hand is to convert this conceptual understanding of built boundaries into analytical units (cf. **Chapters 5** and

8), which can be placed central to a research practice without the immediate reification of categories emerging from them (see Jones 2009). By understanding the socio-spatial complexity of the constituents of the inhabited built environment before devising analytical units, as advocated here, the impoverished understanding which results from subscribing to the over-simplicity of the static, binary character of categories based on observed or measured presence only could be reversed. Dependence on empiricist observed presence stands in contrast to the significance of material presence, which is pivotal in this research.

Boundaries in the inhabited built environment

As the aim is to turn this general understanding of boundaries into determined analytical units that capture their specific type of operation in the configurative composite complex of the inhabited built environment, it makes sense to ask what boundaries do beyond initial differentiation. That is, what happens upon a first linking up of boundaries, what are the first aggregate constellations? **Chapter 3** has already provided the answer to this question. The first entities boundaries form are subdivisions or partitions, and any subdivision is necessarily an inside secluded from an outside by containing an outlined extremity of (or edges to) their extent (cf. Bollnow 1961; Van der Laan 1983; Mekking 2009). All socio-spatial significance of the material presence of boundaries is first and foremost captured in how they seclude an inside (also: me/us) from an outside (also: them).

As part of the inhabited built environment, the partitions perceptible from their outlines in reality are demarcated and characterised by the material properties encountered in the built boundaries of each subdivided space. Through these properties or characteristics each subdivision maintains relations to its outside, its environment, which means through its composition a discretely bounded space cannot be isolated from that environment. In this way, the seclusion effectuated by a built boundary is always relative to the environmental context in which it occurs and it is within this environmental context that emplaced human beings encounter and experience seclusion according to the abilities afforded by physical properties. Importantly, this alerts us that built boundaries can never be captured completely by reference to their abstracted spatial configuration alone (vs. the basic measures in space syntax (Hillier & Hanson 1984; Hillier 2007); **Chapter 6**), but require taking into account their physical properties as well as their materially specific context, affected by their dimensions (as said above).

The marriage of the socio-spatial and physical significance to the act of seclusion has also been noted in anthropology.

> “Humans tend to segment or partition an undifferentiated, continuous environment into bounded space. The environment can be partitioned conceptually through the habitual use of specific activity areas either inside or outside dwellings; environment also can be partitioned physically by means of walls, curtains, mats or other physical barriers [...].” (Kent 1991: 438)

Within Pellow’s (1996) anthropological volume dedicated to boundaries, several contributions actively referred to boundaries’ physical side, especially devoting attention to their presence in the practices of planning and housing (Lawrence 1996; Rotenberg 1996). Herva et al. (2011) add an example of the perceptive ideas associated with accounts of life in a historical urban setting in which materially articulated boundaries furnish the environment. Despite such cases of research sensitivity to the material and physical properties of boundaries within the inhabited environment the boundaries often remain little more than a setting or vehicle for ideational narratives and historical detailing.

Since built boundaries seclude discrete spaces within the inhabited world, it is this operation of their material presence that is acknowledged to be of primary socio-spatial significance. In the inhabited built environment interaction opportunities are always framed in the way the built space occupied is essentially secluded from its outside. So, having accentuated the difference between the historically and socio-culturally contextualised thematic approaches to boundaries, research on the material record of secluding built boundaries is limited. As said before, considering the affective and affording properties of built boundaries composing a built environment, the effort to formalise an ontology of analytical units based on boundary theorisation does not claim to capture such socio-cultural particularities. Instead, boundaries as analytical units have to focus on the causal effects of encountering, introducing, adjusting and crossing built boundaries in everyday life in settling and specifically urbanising societies with respect to the framing of interaction opportunities that they structure. Boundaries as analytical units must allow for contextual empirical identification and positioning of the opportunities for interaction afforded by their material presence within the socio-spatial inhabitation of the concrete world.

The differentiations introduced into the world by seclusions (or 'things') are local and interactional. As Abbott (1995: 863) asserts, "differences are things that emerge from local cultural negotiations. That is, local interaction gradually tosses up stable properties defining two 'sides'." Abbott thus rightfully acknowledges that interaction is fundamental and presupposes actors (inhabiting the world) to perform actions. Interaction is never the *reproduction* of actors themselves or the structures they reside in (i.e. social reproduction), as is assumed in the social theoretical positions of functionalism and rational choice theory, but (in concordance with the constitutive theory in **Chapter 3**) interactive *production*. It logically follows from this that interaction comprises change as the outcome of interaction consists of new or modified actors, relations (which are only partially understood between actors), and entities. "Things emerge not from fixed plans, but from local accidents and structures." (Abbott 1995: 865) If one makes this more precise: things emerge as a result of time-space specific (this is similar to Abbott's measure of propinquity) conditions for colliding biographies of actors (see Pred 1984, 1986) wherein the outcome of interaction and negotiation is the result of intentional acts, but embedded in the outcomes of a multitude of similar ongoing processes which were not intended by those acts. So, to specify Abbott's accidents, it could be said that outcomes of interactions are 'unintended intentionalities'. In addition, due to the ineluctable individual self-referential understanding of the world and subjective ordinal purposes of action, human beings inherently resist emergent structures (*sensu* De Certeau 1988).

In Abbott's (1995) treatise entities and structures, as plans and scripts, can also be imposed by specific actors. He puts these in a processual context as a phase in the construction of entities, which concurs with Star's (2010) conceptual cycle of boundary objects. Resistance to emergent entities and structures as well as imposed plans and scripts, implies that formal administrative and socio-cultural schemas of intellectual concepts are themselves inchoate. Even interactions that seemingly conform to entities always bear within the power of interactive change. Impositions have the same effect as the illusory fixity of extant physical transformations to which actors have no choice but to react and engage with upon encounter, while reproduction of the original interactive intention producing them is necessarily precluded. Planning and building constitute the becoming of protoboundaries (regardless of what these bounded) in the environment and the subsequent linking up of these sites of difference into a single definition for an inside (Abbott 1995) in contrast to an outside, before physically ephemeral consolidation (see above). Initial emergence of the inhabited built environment is part of the process of settling and cultivating the world, while renegotiating or removing physical consolidation are intentional and inadvertent effects of continued local inhabitation within the sites of difference. When we see the seclusions — things — of which the built environment consists as resultant from bounding, everything is in constant formation in the mundanely resistant and subjective interactive process of inhabitation.

Temporally all things and entities — including both human beings themselves as actors and the inhabited built environment they produce through inhabitation — are historically contingent (see Pred 1984, 1986; Paasi 1991). They continue to exist over a period of time, but continuously change in the *perpetuus* of events. Persistence of impositions and physical transformations embody repetitions of interactional instances that occur in a sufficiently similar way. That is, they are repetitions of socio-spatial systemic negotiations, from within and without, of the entities occupied, in the sense of Koch's (2005) constitutive environment and context for interaction (cf. Abbott's (1995) internal reproduction and ecological reproduction). This is not tied to any kind of micro and macro scale boundary seclusions or divisions (see Abbott 1995), but enables research on the basis of a continuous scale in time and space (cf. Vis 2009 on macro scale).

It is easy to overlook that aggregation and linking up of boundaries need not stop at the level of initial seclusion. Beyond a singular subdivision from the inside (i.e. a space surrounded by an outside), built environments, and especially urban built environments, are typically regarded as complex multitiered aggregate patterns. Rather than a single chaotic whole, the (urban) built environment can be regarded to consist of areas of coherence across multiple subdivided spaces, without normative prescription as to what coherence entails. This coherence results from measures of persistence in the affordances of the inhabited built environment giving rise to entities, which over time become part of the emplaced lived experience of its inhabitants. The idea that boundaries precede entities by letting entities emerge from their presence Abbott (1995) calls 'temporal priority'.

> "One could in principle define the neighbourhood system and the potential boundary set and *then* construct the set of which the (potential) boundary set is the actual boundary. [...] in the logical sequence from neighbourhood system to definition of boundary to definition of set we see a logic of increasing specification that could easily be regarded as temporal, an account of the emergence of entities." (Abbott 1995: 861-862)

This temporal priority of the persistence of affordance of boundaries thus gives way to an expression of *mereological causality* (see Smith & Varzi 1997, 2000) in which boundaries as constituent elements of the surrounding built environment (cf. Abbott's (1995) neighbourhood system as a constitutive context) let specific aggregates emerge. "Objects and processes can each be conceived as being put together or assembled out of (respectively: spatial and temporal) proper parts." (Smith 2001: 3) The aim here is not to categorise the emergent entities with increasing aggregate specificity and complexity. Instead the aim is to reveal and understand the way assembled entities cohere as affective and affording patterns in terms of interaction opportunities manifest in the process of inhabitation according to the relational and fuzzy differentiations marked by the properties of the built boundaries they consist of.

The material presence of built boundaries, in the assembled constellations of emergent entities on a fluid scale of the experience of local inhabitation, forms a basis for the study of the socio-spatial phenomena implied by inhabiting and developing a built environment. Our understanding of the socio-spatial significance of built boundaries depends on their measures of persistent affordance, because, conditioned by our perceptive and experiential biographies, we have no choice but to interact upon encounter. This is not exclusive to initially secluded entities, but also the encounter of larger scale coherent aggregate entities of persistent affordance.

Abbott (1995: 873) raised the suggestion that entities have the ability to 'do' social action. Action, then, can be seen "as any ability to create an effect on the rest of the social process that goes beyond effects that are merely transmitted through the causing entity from elsewhere." While such definition of action corrupts the more precise one of purposeful action by Von Mises (1998) used in **Chapter 3**'s theoretical treatise, accepting the effect of any perceived or experienced and conceived entity as *real* is in concordance with the critical realist reading of *causal powers*, which can be of a different nature in aggregate or emergent constellations than its separate constituents. The interactive effects of the materialised presence of (aggregate) entities (*sensu* Wallace's (2011) agency without intent) are pivotal for the social study of the full composite complexity of built environment boundary configurations.

Fiat and bona fide boundaries

Throughout this chapter it has been emphasised that historically and socio-culturally specific boundaries are not explicitly part of investigations here; instead a focus is maintained on the physical characteristics of boundaries that can be readily perceived and experienced. In the search for an appropriate translation of boundary concepts into analytical units in the light of observable information (spatial data) on the physical properties of built environments, the broad protean nature of boundary as a term (also Jones 2009) referring interchangeably to lines, edges, barriers, divisions, etc. needs to be overcome. Despite focusing the research effort on boundaries as an empirical phenomenon, the way they are constitutively understood is not guarded from the imaginary and ideational realm on a rudimentary level. Disentangling the empirical and ideational boundary concepts incorporated in the treatment of boundaries so far is best achieved following the distinction between *fiat* and *bona fide* boundaries as proposed by Smith & Varzi (1997, 2000) and further elaborated by Smith (2001) for various specified kinds of human activity. Employing this scheme will help operationalising boundary concepts in a research practice.

Essentially the opposing definition of fiat and bona fide boundaries is remarkably simple. It is mostly in the way it affects subsequent concepts for research that this basic idea may get complicated. Bona fide boundaries are those distinctions that are based on spatial discontinuity (e.g. holes, fissures, slits) or qualitative (physical) heterogeneity (e.g. material constitution, texture, electric charge). Fiat boundaries are those distinctions that are based on differentiation without association with spatial discontinuity or qualitative (physical) heterogeneity (that is, conceptual or imagined, such as national border and sacred ground). Recognition of this fundamental difference completes the opposition instantaneously. It applies equally to inner and outer boundaries[36], which in theory does not limit their use to any distinction (Smith & Varzi 1997, 2000; Smith 2001).

Both fiat and bona fide boundaries may form entities, or, in Smith & Varzi's (2000) terms: objects. Adapting their examples: bona fide objects could be a body, ball or

[36] In the present (material) context it seems counterproductive and inaccurate to introduce a difference between inner and outer boundaries, because how can it *a priori* be defined what can be regarded as entities, which may then contain or allow for inner distinctions to be made? However, once put in a processual perspective it becomes acceptable that when an entity is established (e.g. a hut) inner distinctions of its parts could be made (e.g. eating and sleeping zones). Since the physical properties of the entity's surface continue, distinguishing one zone from the other would introduce an inner (fiat) boundary.

cheese, whereas fiat objects could be a property, a hemisphere or the North Sea. For the latter, the North Sea, it is apparent that along the coastal lines fiat and bona fide boundaries coincide. One should add though that the lines delimiting the North Sea on maps are entirely fiat. Although one may argue these lines represent the physical distinction between land and sea, we know that the tides are in constant movement. Therefore, no coastline can ever be truly represented by a static boundary. Instead, as some maps will do, it would gain accuracy by depicting the zone of fluctuating encroachment (cf. fuzziness). It should be noted that most fiat boundaries do not exclusively depend on human fiat, but (as phenomenological experience suggests) involve the underlying material properties of a phenomenon also. Bona fide objects cannot also depend on fiat boundaries. **Fig. 4.1** depicts how the basic distinction between bona fide and fiat boundaries works.

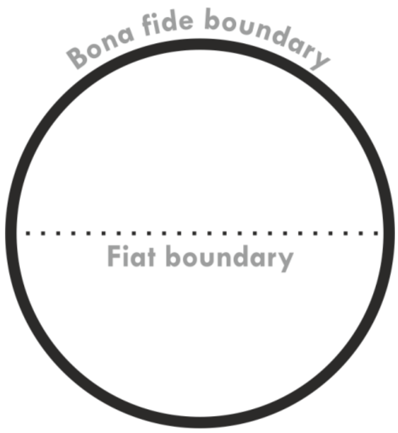

Fig. 4.1: A representation of the difference between bona fide and fiat boundaries
The difference between the discrete (physical) distinction of bona fide boundaries, represented by the solid line of the circle, and the ideational distinction of fiat boundaries, represented by the dotted line, which indicates what we agree distinguishes the upper from the lower half. Note, however, that fiat boundaries can also occur in dissociation from bona fide boundaries.

Smith & Varzi (2000) further distinguish between individual fiat boundaries, and social fiat boundaries. The first kind pertains to the arbitrary choice made on the basis of individual perception and conception and often results from a single act at a given time. This arbitrary choice can also be determined by e.g. a type of measurement or mathematical calculation (e.g. centre of mass of celestial bodies or the equator). Social fiat boundaries are dependent on the perception of the participating human beings (cf. **Chapter 3** on institutional projects and systems) for the arbitrary choice of setting the boundary. In addition Smith & Varzi recognise the more abstract social fiat boundaries that are imposed and therefore *appear* relatively detached from causal change (e.g.

many policy driven and political borders). Finally, it can be logically reasoned that bona fide objects are all connected (in the continuum of the physical spatial world), whereas fiat objects may be scattered. Simultaneously, some of the scattered fiat objects may be unified in fiat objects of a higher order: e.g. island groups. It is useful to note these further distinctions as they can be readily connected to the preceding theorising in this chapter and **Chapter 3**. Moreover, it should be noted none of these distinctions changes the first definitions of fiat and bona fide boundaries: a boundary refers to a physical distinction or it does not. As data on urban form and spatial layout contained in the composite complex built environment results from documenting and measuring observed physical differences, this philosophical assessment of boundary concepts is highly beneficial for coming to terms with the how and what of the empirical reality our data truly represent.

Next we delve further into the implications of the concrete empirical world. Because bona fide boundaries are material, i.e. they have divisible bulk or mass, they necessarily occupy space. They must be part of the entities, bona fide objects, which are circumscribed by them. That means that bona fide objects ineluctably comprise their own boundaries, whereas the environment they are embedded in is open (cf. Ingold 2008a). Bona fide objects thus have open complements. Holes and tunnels, however, are notable examples of where this seems to work the other way around. These are called negative objects (Smith 2001). Where a void occurs in the surrounding material surface the resulting bona fide object is defined from the outside by the bona fide boundary of its 'host' (Smith & Varzi 2000; Smith 2001). Negative objects cannot be true bona fide objects, as they need fiat boundaries to completely circumscribe them as an entity. That is, the entrances are not bounded by (observable or experiential) bona fide boundaries but ascribed to them by human fiat (Smith 2001). That is, fiat e.g. separating the air filling a hole from the outside air or the contiguous ground surface (this idea is taken forward in **Chapters 5** and **7** with 'virtual boundaries'). Accepting the open complements of bona fide objects does not imply that when a bona fide object is divided (by fluxes or interaction) it leaves one part open and the other closed (because it comprises the boundary). Instead, the extant outer boundary of the bona fide object is progressively deformed and becomes two surfaces (one for each now separate bona fide object) (Smith & Varzi 2000).

Recapitulating, boundaries as sites of difference are a way of better understanding differentiation, the recognition that something is not something else. The process of differentiation works continuously through all concepts, perceptions, and experiences coming forth from inhabiting the concrete, socio-spatial world. The physical properties of the spatial world lead to differentiation according to bona fide boundaries. In getting to know the world we have the capacity to project divisive fiat boundary conceptions onto and next to those physical differences. Except for recognising our fellow human beings as physically present entities, most differentiations in the social world are fiat boundaries, i.e. arbitrary, ideational decisions, while in the concrete inhabited world many of the fiat distinctions make use of underlying physical differences.

Following from the time-geographical principles of Hägerstrand (1975, 1976) it has already been argued that the same spatial location cannot be occupied twice. This logically means that bona fide boundaries cannot coincide, as is indeed acknowledged by Smith & Varzi (2000: 416). However, "fiat boundaries, because they are not possessed of divisible bulk, do not occupy (fill out) the space where they are located; hence they can be perfectly co-located one with another." This notion is critical for understanding how the concepts devising our built environment data come about.

Conceptual series towards spatial data

Ideational and empirical boundaries

Bona fide boundaries may give rise to and coincide with fiat boundaries and fiat boundaries may give way to additional (modified or higher level) fiat boundaries. However, the only way a fiat boundary can become a bona fide boundary is through the according transformation of the physical properties of our environment in the interactive processes of inhabitation. This human construction process has been designated materialisation before (**Chapter 2** on the material and **Chapter 3** on filled space). From that moment onwards the differentiation enters a dialectic relationship in which the fiat boundary and the bona fide boundary continually become one another (cf. Pred 1986). That is, the processes of formation are inchoate (cf. Jones 2009), thus ongoing, while the bona fide boundary and its modifications and/or transformations become an immediate empirical and social reality of material manifestation in space that is reacted to in the same human and social way as otherwise would have been the case. That means the ideational (human or social conception) becomes the empirical (material through physical transformation) and the empirical in turn influences the ideational and so on.

Built boundaries

As previously mentioned in the boundary theory above, boundaries resulting from materialisation we call built boundaries. This expresses the fact that materialisation comprises constructive human interactions within the environment whereby its pre-existing physical properties are transformed. The making of built boundaries introduces additional physical discontinuities in the environment, i.e. the edges of built features. Built features are intended to be further occupied by inhabitation processes. They are physical things, a surface or textural extent of a mass of substance, comprising their own boundaries to an outside or open complements. These boundaries, perceived of as edges, compose the built environment complex. The built environment thus consists of bona fide boundaries.

Although built boundaries as edges still simply refer to one physical space as distinct to another and are therefore essentially part of that bona fide object, in constructing occupiable physical subdivisions built boundaries can have mass themselves. That implies the boundaries themselves essentially become a bona fide object as not only their distinction, but their masses occupy space. The masses of the built boundaries which by their bona fide distinctions circumscribe other (internal) bona fide objects may be important for an ontology of the entire ecological world, but have no decisive part in this research. Their space is already occupied and therefore cannot serve simultaneously for human occupation necessary for social interaction opportunities. Yet, insofar as the characteristics of the mass of boundaries that themselves occupy space influences the relation to the outside or open complements, this physical information can affect our understanding of the precise role their distinction plays in the built environment complex. Regardless, all built boundaries are measured and documented as part of acquiring data on the material and spatial configuration of the built environment.

Boundary lines

In documenting the material-spatial properties of the built environment, the edges of the physical distinctions formed by built boundaries become boundary lines. This means they represent all the measurements and observations that were part of the empirical spatial data acquisition. As representations, boundary lines are fiat boundaries. Boundary lines, as such, do not occupy space, but convey an ideational meaning. They are reductions from the (physical) edges of bona fide objects in the built environment. This reduction needs to be further specified for those bona fide boundaries that themselves comprise mass. As mentioned above, the space they occupy cannot serve simultaneous human occupation (on the same (ground) level). Hence, in the representation of the edges formed by built boundaries, edges will refer to the outlines of bona fide objects which for materially demarcated boundaries include the extent of their mass. The effect for our data is that when a built boundary comprises mass, i.e. is itself a bona fide object and circumscribes a subsequent bona fide object, the documented boundary line will represent the edge that is the outline of the circumscribing built boundary. The spaces that are distinguished by all edges so documented are generally thought of as, at least in principle, available to accommodate occupation by (a) human being(s) (i.e. a socio-spatial system).

It is thinkable that in particular built environments built boundaries consist of a mass that is actually occupiable itself (e.g. thick castle walls) and could on that basis be considered as a spatial subdivision. In such cases the researcher should duly declare how this is treated in the data. For the purposes of this study occupiable built boundaries will be considered to be part of the inside space of subdivision created.[37] In lay terms, the outer limit, or the outside edge, of a wall thus becomes the outline and therefore the boundary line representing the spatial subdivision. It is a pragmatic and purposeful (for comparative reasons, see **Note 37**) arbitrary decision on resolution not to include the mass of boundaries (even when occupiable) in the context of this research.

In addition, in our data, when such a materially demarcated built boundary leaves a gap for passage that entails a physical discontinuity on the ground surface, the boundary line representing it will still circumscribe the feature as a closed and discrete subdividing outline. This will ensure that a basic visualisation of the spatial data is produced, which consists of equal boundary lines representing outlines[38]: an equal fiat

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[37] The proposed reduction serves the additional purpose of creating data of equal quality for every thinkable case study across cultures, geographical locations, and historical periods. This allows data to be derived from various disciplinary conducts, including in cases where a spatial configuration of the past can no longer be fully retrieved and empirically documented. As will be shown in Chapter 7 it is thus possible to make use of conjectural datasets of spatial configuration with very incomplete empirically verifiable data available. A careful and critical practice of reduction to boundary lines should secure the comparability of data.

[38] In most contemporary and modern historical plans and maps the components of the built environment are represented by exactly such indiscriminating outlines, which very often appear as equal lines on the map, though their exact treatment of the mass of built boundaries is unclear (cf. Chapter 7). The convention of OS MasterMap (*OS Mastermap® Topography Layer: User Guide and Technical Specification*, 2007) (in the UK) uses the term 'mereing' to describe the definition of any

representation of the differentiation between one spatial subdivision and another. There is, however, a level of detailing involved that is always at the discretion of the individual mapper or researcher. Depending on convention and research or analytical purpose, either per particular built environment or ensuring comparability across datasets, outlined subdivisions could occur on very small scales indeed. As will be explained theoretically below, here a distinction is made between edges of a major occupiable subdivision and those further physical distinctions that logically refer to the precise use and design of that subdivision internally rather than how it relates to its outside.[39] Depending on the nature of the data and the purpose of analysis more or less detail could be allowed to appear at outlines of spaces in the boundary lines. Outlines, then, can be seen as the schematic sketched representations of the boundaries as sites of difference giving shape to an entire built environment complex.

Visualised or presented data

On the basis of documenting separate boundary lines, a fiat outline drawing of the configuration of the built environment can be made. Naturally such a visualisation or presentation of material-spatial data neither shows mass dependent physical properties nor the ongoing inchoate processes of which the represented bona fide built boundaries are part. So, paradoxically, despite understanding built boundaries to be subject to constant (re)negotiation, their data representation depicts an eventful state in which no transformation whatsoever takes place. They will only ever be an 'accurate' representation of the bona fide boundaries reduced on the basis of human fiat, and an approximation of the fiat boundaries informing the constant formation in time-space specific inhabitation processes.

The fiat outline drawing could be designated a map. It should indeed be noted that specifically through this process we have demonstrated that well-prepared ground plans can be used for the social study of built environments based on boundary concepts. However, our traditional view of a map as a static snapshot that appears to refer to a degree of *continuity* needs to be adjusted. The eventful state that is depicted in fiat

relationship of mapped boundaries, such as districts and counties, with real life (empirical on the ground) features. Such definitions, however, are not available for each coincidence of a mapped fiat boundary line with a bona fide boundary.

[39] Some easily recognisable examples of such distinctions could be the rooms of a building, flower bed designs in or paths through a park, the pedestrian areas (sidewalks) distinguishing the intended method of transport along streets, etc.

boundary line maps should instead be regarded as atomic[40] (all occurs at once and is inseparable). Any next atomic stage essentially depends on the occurrence of any change (to the physical properties of built boundaries), because all change relationally changes everything that is included in the depicted whole. If maps are used in a series of 'time-slices' of a continuously inhabited place they can be related to analyse its historical development, because we know each time-slice is atomic while we understand the same inhabitation processes (as theorised) are ongoing between them. Therefore one time-slice logically develops into the next. Looking at time this way is 'eventful' history (cf. Smith, A.T. 2001; Vis 2009 on temporal rhythm) though each time-slice's precise historical 'weight' cannot necessarily be discriminated in relation to longer termed continuity (cf. Bintliff 2010). Yet, its socio-spatial significance in part is interpretable through persistent physical characteristics within the built environment complex, which may feature, thus influence, over long periods of time. Intellectually, though, persistent built boundaries are not identical over time, because with every change the constitutive context of all boundaries within the whole changes.

What in such atomic approach is lost, are all the intermediate stages (down to the smallest temporal particle). The better the temporal resolution the more detailed the analysis can be. While the origin of built features can be expected to be temporally diverse and therefore the map represents a palimpsest, one should be careful not to introduce anachronisms in the data, implying that special effort should be made to make sure all features mapped did indeed exist contemporaneously at the moment ascribed to the map. Anachronisms could occur if there is a better historical resolution for one building, but not the next. Except for conjectural (see Lilley et al. 2007; Lilley 2011a) and historically reconstructive (Keene 1985; Bisschops 2012) mapping, one should aim for the nearest possible to a comprehensive snapshot of the area under scrutiny. However, it should be noted that in most cases such level of precision is not achievable, which is why it needs to be clarified which assumptions are made about the source data used.

Towards an ontology of analytical units

In the conceptual series above we have worked towards a better understanding and appropriate convention for material-spatial built environment configurative layout data.

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[40] Atomic here is used in the sense of atomicity. An atomic moment is inseparable: no time passes and everything occurs at once. A map in this sense is a representation of something immediate.

The next stage is the formulation of analytical units, which need to unite the theoretical understanding of boundaries both on the fiat and bona fide side as well as the fiat and bona fide understanding involved in conceptualising built environment data. The implications of these oscillations between fiat and bona fide boundaries for preparing our data and devising a research practice based on commensurate analytical units is summarised in **Table 4.1**. The table comprises four stages, after the ideational and empirical difference of boundaries, in which spatial data becomes converted into appropriate boundary conceptualisations: from the initial acquisition of spatial information, through to processing that information into meaningful ascriptions which lead to analytical units.

	Built environment data type	**Nature**	**Acquired as**	**Format**
1	Built boundaries	Bona fide	Measurements and documentation of physical transformations of the environment, i.e. materialised differentiation	Unprocessed empirical observations (data as acquired)
2	Boundary lines	Fiat	A construction and reduction to the outlines of the full, continuous extent of materialised differentiations	Processed and simplified version of empirical observations
3	Boundary visualisation	Fiat	A geographical representation of the outlines	Integral interpretive geographical organisation in an outline plan (full configuration)
4	Boundary line types	Capture a fiat understanding of bona fide	An application of an ontology of analytical units on the outline plan (boundary line type ascription)	Dissected plan of geographically anchored analytical units

Table 4.1: Conceptual breakdown of material-spatial layout data on the built environment
This table breaks down how material-spatial layout data on the built environment can be expressed according to the principles of bona fide and fiat boundaries.

A few things should be noted following the data breakdown in **Table 4.1**. Firstly, the methodology that is emerging here offers an idealistic presentation of data acquisition. As indicated before, in practice it could logically be expected that researchers will use already extant maps and plans, both commercially and academically produced (from various disciplinary conducts) as well as historical documents, historically reconstructed and conjectured maps. The advantage is that 'legacy data' produced for other purposes could be adapted for applying boundary concepts. It should be noted, however, that extant data and plans require treatment with meticulous care. Ambiguities in the reading of mapped material without direct checks of the empirical reality they sprung from are unavoidable. **Chapter 7** will present two test case examples of the treatment of divergent data sources for this purpose.

Secondly, the production of, or reduction to, outlines conceals their underlying intricate theoretical provenance. Outlines should logically follow from adherence to a single coherent (the smallest scale) continuous residing socio-spatial system. As the internal arrangements of the functioning and activities of ongoing residing systems cannot be known from the theory, the internal connections or interior design of space(s) within outlines should not be represented. The definitions of the analytical units (see **Chapter 5**) will help to make informed decisions at this stage, though a degree of subjectivity in judgment calls and purposeful conventions cannot be avoided in practice (**Chapter 7** discusses this for the test cases). Another way of seeing the argument on built boundaries with an occupiable mass made above is to regard this mass as part of the internal arrangement.

Finally, it should be noted that **Table 4.1** does not explicate the temporal congruency that needs to be assumed in spatial data. The ultimate assumption, as explained above, is that a mapped representation is necessarily atomic, even though it is recognised that the nature of any plan and data acquisition prohibits true (immediate) simultaneity. However, in data acquisition of whatever kind one should critically assess the historical and/or archaeological determination of the temporal span included in the data provided. Only assuming atomicity of spatial data can allow for analysis of material boundary properties across space, as the dataset needs to be complete and to represent features that are known (including critical conjectures of data gaps in the contiguity of the spatial selection, see **Chapter 7**). Analytically such 'spatial moments' can be connected through time (**Chapters 8** and **9** discuss issues related to diachronic analyses).

Table 4.1 concludes with 'boundary line types'. **Chapter 5** will be dedicated to how these are defined to form ontological descriptive operatives forming the inhabited (urban) built environment. As mentioned at the outset, these analytical units will distinguish the types of seclusion operated by the physical properties of built boundaries as they occur in emplaced lived experience. They construct the missing link between a theoretical socio-spatial understanding of the inhabited built environment and an informed empirical study based on spatial data. As such they form the concluding step in formulating what could be called an empirical theory as argued by Smith (2011a): the connection between high level (social) theory and empirical application. The ontological definitions serve the double purpose of empirical identification and interpretive understanding of the constituents of the inhabited built environment, specifically differentiating between the socio-spatial systems occupying or residing in its initial spatial subdivisions and further perceived aggregate entities.

CHAPTER 5 – AN ONTOLOGY OF BOUNDARY LINE TYPES

Introduction

In the course of the preceding chapter abstract theory on the inhabitation of the world came to be connected to built environment data by means of boundary conceptualisations. We moved from a thorough understanding of boundaries and a world of bounding processes to a foundational conceptualisation of what is conveyed by basic material-spatial outline data on the layout of the occupiable subdivisions composing the built environment. This may provide the basis for regarding (urban) built environments as a complex boundary configuration to be visualised as simple lines on a map, but such reduction almost completely conceals any path to further investigate the specific socio-spatial significance of any specific case.

As it has been established in **Chapter 4** that the socio-spatial significance of all boundaries is primarily captured in how they come to seclude one space from another, a study of the socio-spatial significance of the material presence of boundaries requires analytical units exclusively defined as distinct operational interfaces of seclusion. The kind of operational interface of seclusion each section of boundary conveys depends on the physical and spatially contextual properties of the built boundaries as they occur in emplaced lived experience, now imagined as lines. However, the successful application of the ‘boundary line types’ **Chapter 4** concludes with as analytical units depends on a definition that simultaneously permits their exclusive identification as line sections in the spatial dataset, aided by knowledge of the empirical (material) reality it is derived from. That means that definitions should not only determine the material properties of built boundaries that are intellectually understandable as a kind of seclusion, but also include a precise reference to the physical and configurationally contextual properties that situate them in particular locations and their extent within the built environment complex. In this way these *primary analytical units* (**Chapter 8** will explain how further analytical units can be derived from them) will form the hinge between a theoretical understanding and the enabling of comparative empirical operationalisation. It is only through operationalisation that profound yet broad knowledge on urban life and the developments of urbanisation as parts of the human inhabitation process can be produced for specific places and that urban traditions or geographical areas as well as meaningful contrasts between urban landscapes can be specified.

In other words, this chapter aims to supply a culminating set of concepts, i.e. Boundary Line Types (BLTs), which serve a *purpose* as primary analytical units. However, this set of concepts differs from before, because combined they should provide the elements for a full *ontological redescription* of the built environment conveyed as boundary lines with a view to applied empirical research. This means the definitions of the analytical units contained in this chapter form an empirical theory (*sensu* Smith 2011a) on the basis of which a *method* for their study can be devised. In the back of this thesis a supplementary table of abridged BLT definitions can be found for easy reference throughout the remainder of this work.

Requirements for the ontology

All conceptualisation up to this point was a necessary preparation to enable the use of (urban) built environment data in an accurately defined and informed way. Through this theoretical process it is now known exactly what we are interested in and looking to understand from analysing such data. Yet, in order to acquire analytical units we need to dissect the boundary lines depicting the built environment into secluding sections comprehensively. In other words, we need a boundary line type ontology (see **Table 4.1**). In the terms of Koch's (2005) architectural systems, the elements of the spatial system need to be defined on the basis of the architectural structure they receive. This architectural structure comprises the material properties and references to the physical and configurationally contextual properties on the basis of which they can be identified, as mentioned above, but does not prescribe location of occurrence and dimensions. Yet, once empirically identified, both the extent and relative position and the persistent properties will be informative for understanding built boundaries as fixed approximations of inchoate socio-spatial significance, for which their specific seclusion sets the terms of the theoretical part of their definition. Positive identification of line segments as BLTs principally depends on the visual inspection of the spatial contexts in which they appear, and any available information on the empirical reality at the time of mapping their occurrence (this means also the historical period intended to be captured by reconstructive and conjectural mapping efforts[41]).

Kropf (2009) cogently argues that a usable (comparative) ontology should respect certain requirements. These consist of a consistent, coherent and comprehensive set of definitions, which are general enough to be used comparatively in all thinkable contexts, yet specific enough to identify them as analytical units in the empirical reality of datasets. Hermon & Niccolucci (2002) show that when a general typology of flint tools for prehistoric research was devised, similar requirements were met for application to specific time periods. Because the notion comparative here intends to span the full variety of urban traditions as they evolved worldwide, throughout human history (see **Chapter 1**), the terminology used in the definitions should avoid terms that are suggestive of particular use and socio-cultural contexts as these depend on additional time-space specific data on each city, always remaining on a flexible and rudimentary human conditional level. The BLT definitions should fully support an ontological redescription of any urban built environment complex on both disaggregating and mereologically (cf. hierarchy in Kropf's (2009) ontologies: resulting from the causal relation between parts forming entities) generative levels of constellation and aggregation.

What is proposed here could be called an 'ontology of types', which should mark the difference from a full metaphysical ontology which also includes the precise relation between elements. The BLTs must presuppose to represent the whole of that which they are part entirely through relations, but, apart from certain conditional statements, how they are related is contingent on each time-space specific situation. A critical reader might remark that creating types actually means retreating into categories[42] once again (cf. **Chapter 4**), though this time the categories capture the boundaries themselves as abstracted entities. There is no way to completely avoid this paradox. Empirically BLTs are immediately recognised as 'entities', i.e. analytical units. They do represent the physical demarcation of the socio-spatial specification of 'differences in character', using Abbott's (1995) words. Therefore it is useful to emphasise once more that boundaries are emergent and constitutive contingencies, as in Jones' (2009) inchoate processes, to which in (scientific) observation and day-to-day experience we assume and ascribe a fixed reality.

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[41] There will be further attention for reconstructive historical mapping and conjectural mapping in Chapters 6 and 7.

[42] Schaffter et al. (2010) articulate an insightful subdivision of categories in type, class, and concept.

Actually, the BLTs do not represent a full concrete reality, but merely abstract a situation springing from the material presence of boundaries. This chimes better with Abbott's (1995) assessment of boundaries as 'sites of difference' (on the basis of a property), which should be regarded as atomic[43] units (a point or site) to which differences can be attributed. This same logic can be applied as a description of BLTs, which represent the sites of an elementary operation in terms of the secluding differentations that are empirically discernible on the basis of the foundational informing theories. As such, it could be argued we are no longer talking about units or categories, but determinant elements.[44] The initial mundane *entities* coming forth from linking up these elements are not a primary concern in elementary identification. Rather, of concern is their direct and wider contextual placement in association with their configurationally or topologically affective properties, intrinsically positing an empirical social reality (that is, an experiential locale for social interactive processes).

On the basis of an ontology of BLTs, the boundary line visualisation of a built environment complex can now be 'dissected' into segments commensurable with their definitions. This process of remapping itself automatically leads to an analytical or formal redescription with an immediate initial alternative visualisation of the inhabited configuration. Since identification appeals to a flexible human appreciation of a more than abstract empirical reality (as if encountering the situations on site), mapping according to the BLT ontology cannot currently be automated in a computational process. Nonetheless, as a mainly visual process compatible with application on digital data, mapping BLTs opens up an array of hypothetically meaningful quantitative, statistical, and analytical operations of ordering and extracting information advancing human interpretation. In turn, more selective or immediately intelligible visualisations could be based on these interpretive measures. Patterns representing entities and aggregates emerging from the boundary relations and processes intrinsically part of each time-space or case specific urban built environment could be explored (**Chapter 8** will discuss interpretively promising analytical possibilities). Both disaggregative detail

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[43] It is unclear what Abbott (1995) intends with his use of the word atomic. It could be he means to express the 'smallest part'. However, the fact that he refers to them as 'points' indicates an abstract representation, a reduction of something extant.

[44] It should be noted that this depends heavily on the way the theoretical concepts leading up to BLTs are defined and how the reduction (boundary lines) took place. Depending on these definitions and preparatory processes the operational elements referred to could acquire a different definition. By the same measure, someone interested not in configuration and configurative affects but the specificity of all material properties would probably arrive at other definitions.

and aggregative patterns may *represent particular occurrences of inherently inferential socio-spatial significance in terms of from-the-inside-towards-the-outside relations within accordingly framed interaction*.

This interpretive potency does justice to Jones' (2010: 266) "insistence that categories do not have an intrinsic meaning and that their boundaries are always inchoate[, which] is an attempt to disrupt the apparent fixity of the categories ordering the world." In contrast, the intrinsic logic of BLTs redescribing urban built environments (cf. Löw's (2013) intrinsic logic of cities) lies in their emergent contextual relationships forming *a posteriori* recognised entities, not the potential correlations with *a priori* assumed lay categories. This concurs with how we get to know the world phenomenologically and to Jones' (2009) suggestions of cognitive processes, though it replaces any acculturated arrogation of Schütz's (1967) 'common stock of knowledge' with Sayer's (1985, 2000) emancipating understanding. This does not withstand that questions of interest could be elucidated by correlations uncovered through combining the socio-spatially relative positions of entities with e.g. historical, archaeological, social or anthropological assemblages of information. Ultimately, entities on any scale recognised and understood through a boundary approach emerge from the intrinsic coherence of boundaries in the whole complex as a constitutive context and do not prescribe their precise forms (see **Chapter 4**).

Formulating a BLT ontology

The following paragraphs will summarise several specific stipulations to which the ontology of BLTs formulated below must adhere. This ensures, in addition to all else, that the data treatment which the definitions require also maximises comparability.

Since we theoretically depart from a position in which human beings are emplaced in the urban built environment and therefore by inhabiting it occupy the subdivided spaces boundaries seclude, the from-the-inside-towards-the-outside notion of the emergence of discrete occupiable entities implies the inevitability of the two sides to each boundary. Although boundaries as an abstract 'site of difference' could be atomic, they have come to incorporate physical properties as built boundaries which will necessarily feature dimensional extents. An emplaced human being encountering a materialised differentiation will always be relationally placed to face or approach one side of it. If the affordance of a boundary to be traversed is realised, i.e. a human being crosses the boundary, this relationship is inverted. Individually we are always on the inside looking out: this situation cannot be inverted even though the relation to the boundary crossed will be. Therefore when on the inside, we understand the potential of a situation of being on the outside (looking in). To take full account of both positions in relation to the boundary, a BLT definition needs to refer to a boundary from both sides. Extending this argument contextually to the subdivisions that emerge from built boundaries, no boundary line can ever become fully defined by the identification of a *single* BLT. The redescription of a built environment of boundary lines depends on emerging contexts the boundary is part of on both sides. When more than two BLTs are identified along a segment of boundary line, this will be the result of mereological conditional statements in the BLT definition by which some relations become necessary though not specified.

As the specific way in which seclusion operates depends on how the built boundary is characterised by its material properties, it should be noted that material properties can account for tremendous levels of detail, including architectural textures, style, form, tradition, and construction (e.g. Kropf 1996). Because the aim of this ontology is to enable application in comparative research, the *level of detail* needs to be determined on which material properties are deemed relevant. Since many material details can evoke all kinds of sensory and intellectual affects, it should be clear that this comparative aim causes a deliberate limitation. This aim neither purports to be final nor a literally all-encompassing redescription of the built environment. Alternative aims or inclusion of additional or alternative empirical information would logically lead one to a new commensurate conceptualisation. Here the imposed limitations, especially caused by the restrictions of archaeological remains and historical reconstructions by which temporal depth is enabled, initially boil down to major outlines on a close-to-ground level. Close-to-ground means more than a two-dimensional line, but less than comprehensive three-dimensional information on built volumes, being limited to the ground surface configuration and the influence of obstructions and passages across its subdivisions. The most determinant occupiable spaces and the basic materalisation of their relations should then remain detectable or retrievable through time in a much larger number of well-known or preserved cases. Datasets from prehistory to the present day can be conveyed on the same level of detail. Ideally, it is intended that a trained eye could begin investigation of mapped data with some background information on the empirical reality of encountering the boundaries, but without elaborate background research. However, it cannot be done solely on the basis of unknown line drawn maps, because in order to discern how boundary lines affect opportunities of interaction within the reality of inhabiting a socio-spatial and physical environment, all material properties directly affecting how each seclusion of the contiguously connected subdivisions takes place, should be taken into account.

Contrary to the elicitation of ‘seclusion’ it is determined from here on that in principle all boundaries are crossable and, therefore, open: accessible or permeable. This accounts for the societal necessity to move between spaces in order to function and the fact that built boundaries change over time. The material properties of ‘open’ boundaries can be regarded as passive or nonobstructive (e.g. intersected) in the sense that they readily allow traversing. Yet, it is promptly acknowledged that certain built boundaries will literally have to be broken before a crossing and, consequently, direct interaction can take place.[45] Such boundaries, e.g. impermeable walls, form barriers to regular crossings, meaning undisruptive interaction between the sides concerned is not possible. The material property of impermeability is therefore of great importance to the BLT definitions. As the operation of seclusion has *ontological primacy*, the formulation of the BLTs will start with a determination of the ability to close off (make impermeable) a bounded space (subdivision) towards undisruptive interaction from the outside, i.e. a strongly emphasised seclusion from within and necessarily ‘intrusive’ interactions from without.

The notion of closing off from-the-inside-towards-the-outside results from the understanding of a socio-spatial system occupying or predominantly residing in the spatial subdivision concerned, by which it distinctly extracts itself from the surrounding environment. This also retains the exertion of a mundane spatial power relation, because the same space cannot be occupied twice (Hägerstrand 1975, 1976; Pred 1977) — neither by the mass shaping built form nor by people simultaneously — and thus space is dominated by this seclusion. Closability, then, depends on the physical characteristic of the material properties making a boundary impermeable. As a consequence of the dominant relationship caused by closability (the ability to make impermeable), surrounding BLTs may have a configurative association of dependence. This also implicates that there is an inherent interest in entranceways (Latour’s (1992) wall

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[45] It could be suggested that an actual crossing is not a necessity for social interaction, even through a wall. To what extent material properties are permeable is difficult to determine without direct observation of their properties and sensory functioning. E.g. what thickness or which material makes a wall numb sound completely (see also Rodman & Cooper 1996)? Assessing this requires experimental and observational material research. More sensitive and comprehensive sensory approaches in anthropology and archaeology can be found in, e.g. Bull & Back (2003), Howes (2005b), Drobnick (2006), and Boivin et al. (2007).

holes), as depending on the material properties these either afford closability (e.g. the temporary manipulations of opening, closing, and locking a door, or Latour's (1992) door hinges rendering a wall hole in a reversible state) or, alternatively, predominantly mitigate impermeability.[46] As a physical characteristic, the dominant designation could be used more flexibly to further specify a BLT or a particular complex of BLTs.

Currently two kinds of dominant BLTs are distinguished: a *dominant* and a *solid dominant*. The latter refers to the single cell configuration (Hillier & Hanson 1984, the simplest configuration of a single space with a relation to its outside) or the single room house (e.g. M.E. Smith 2008). Because the BLTs are based on outlines, and thus disregard internal organisation or interior design, most outlines of structures or buildings would be designated closable boundaries and become solid dominants (i.e. no further differentiation inside).[47] Only through a hierarchical relation, typically an 'enclosure', can dominants create aggregated subsets of boundaries, whilst retaining their closability. Solid dominants could operationally be seen as the mother of all BLTs. However, the primacy of the solid dominants should not be mistaken for a lived experiential primacy for emplaced human beings encountering the world. There is no necessity in any instance of *terra incognita* in the world we encounter that our experience of it starts with spatial distinctions characterised as solid dominants (in any case we have to introduce them first as built boundaries). Nevertheless, it is not coincidental that the human construction of built environments depends first on secluding spaces from each other. The simple construction of a shelter or home bears the physical, architectonic characteristics of a solid dominant. This theoretical understanding of significance is not the same as the primacy of identifying solid dominants in research practice, which follows from the situation of being faced with a pre-existing spatial-material dataset: i.e. the static and holistic selection of an already constructed built environment in which we are not ourselves currently embedded.

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[46] It is worth noting that archaeological evidence may be very fragmentary and, without onsite inspections, even modern maps give little conclusive information on entrances and where they are placed. Their location remains therefore to an extent a matter of informed conjecturing and expert judgments (see also Chapter 7). It would be practical to assume any spatial subdivision in principle is enterable for someone, unless there is evidence for the material property of impermeability along the boundary's course. It is acknowledged here that full onsite surveys of material properties would be commendable, but often unfeasible.

[47] Solids are closely related, though not accordant, to the definition of architectonic space of Van der Laan (1983). Similarly, though the architectonic distinction between solids and voids is inevitably elicited, the term solid dominant is not equivalent to the use of solids in architecture.

It applies to all non-closable boundaries that any demarcation with the material property of impermeability requires the presence of transcendent intersections. It is conceded that validating their existence often requires informed assumptions and critically judged simplification, which is a sacrifice made to the ready applicability of the BLT definitions. However, this does not mean that the ontology presented should be seen as a total prescription to the level of detail permitted by any individual researcher. In principle, acquiring or retrieving the required empirical evidence will allow any boundary to be identified as closable and therefore change its socio-spatial role into a dominant seclusion.

Following the meticulously theorised premise of the inhabited urban built environment it is inevitable that the physical characteristics of its constituent contiguous spatial subdivisions permit occupation to such a degree of permanence that a particular socio-spatial system (see **Chapter 3**) can inhabit (e.g. reside in or structurally utilise) it. In the continuous process of inhabitation the way a socio-spatial system is established, (re)negotiated, perceived and experienced is responsible for the volatile and flexible intellectual understanding associated with the materialised ephemerally fixed approximations that are built boundaries. Defining a BLT that cannot pertain to a partial description of an inhabited spatial subdivision, because it cannot be (predominantly) occupied for example, produces socio-spatially a 'negative space' in the contiguous complex. The effect of this is comparable to Smith & Varzi's (2000; Smith 2001) negative objects: a void bona fide object is defined from the outside by the bona fide boundary of its 'host' material surface surrounding it (see **Chapter 4**). Because the reasons for a spatial subdivision being defined as negative can differ, it is deemed advantageous to define several BLTs pertaining to negative socio-spatial designations. This allows the contiguous boundary complex of the urban built environment of a locus (such as determined in **Chapter 1**'s definition of the city) to be redescribed entirely, and furthermore enables the imposition of a natural (built environment or city limit) or artificial (data selection) end to the area being studied.

Implicitly repeated in all of the above is the consequence that each BLT is not a concrete object. Although defined and identified separately, BLTs cannot exist in isolation and cannot form the empirical social reality of material presence. Instead, they are still abstract concepts to overlay the reduction to boundary lines visualised as an outline map of the urban built environment. Any built boundary conveyed in this way can only be fully described and understood in socio-spatial terms by considering all BLT identifications it received together. It is a well-known entailment of all maps that they 'lie' or at least never convey an incontestable truth (Monmonier 1996; Wood 1992; MacEachren 2004; Lilley 2011a, for critical historical assessments of how (lying) maps are used, see Clarke 1985; Hutson 2012; Lilley 2012; Beisaw & Gibb 2013). Better said, all maps abstract or select information in a particular way, which is similar to how the theoretical conceptualisations throughout this research abstract, and, therefore, fail to contain the entire concrete truth (see **Chapter 2**; Sayer 1981). When working on or with mapped representations it is worth bearing in mind that such all abstractions are interpretations conducive to particular understandings themselves. Therefore, in using the BLTs, one should always be alert not to mistake the empirical abstraction for the empirical reality posed by the material presence of built boundaries.[48] For that reason the BLT definitions will be illustrated with photographs rather than on examples of outline map visualisations which are likely to be used in analytical practice (see **Chapter 7**). As said before, the use of maps, and thus reductions, requires at least some prior knowledge of and critically judged assumptions about the empirical reality represented. In contrast to maps, the illustrating photographs deceptively show potentially confusing 'real world' detail, which would be omitted through the process of preparing an outline plan.

Finally, and importantly, the formulation of BLTs is a direct product of a process of iterative abstraction (Sayer 1981, 2000; Pratt 1995; Yeung 1997) as discussed at length in **Chapter 2**. This means that what is presented is the most current outcomes of several instances of abstraction, in which initial and subsequent conceptualisations were contrasted to empirical data[49] by attempts to apply them. Here the criteria were first and foremost that altogether the ontology adhered to the requirements in the covenant of Kropf (2009): to be consistent, coherent and comprehensive set of definitions, which are general enough to be used comparatively in all thinkable contexts, yet specific enough to identify them as analytical units in the empirical reality of datasets. That means that

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[48] Blaut (1971: 19) insightfully wrote on mapping processes, which would include using BLTs: "[…] the resulting 'structural model' [the mapping], although abstract, refers back to processes, if it refers back to the empirical world at all. This is true even if the model depicts, as a map does, *spatial* structure: as we have seen, the map sign-system does not signify pure space, which is unmappable, but rather draws attention to two spatial dimensions and certain other selected properties of selected phenomena, explicitly (if less noticeably) signifies their temporal dimension, and artfully erases away remaining properties along with all the other phenomena which disappear into the 'ground', the white spaces on the map (which, of course, have process meaning too)."

[49] The data used to test this concerned subsections of mapped representations of Winchester (UK), Chunchucmil (Lowland Maya), and Ostia (Roman), the former two of which will be used as strongly contrasting test cases in Chapter 7. Examples from a range of places (historical and contemporary) were used to ensure the BLTs have the widest possible comparative applicability.

the test applications should demonstrate that all boundary line data is redescribed entirely and all boundaries could be positively and exclusively identified (though some expert judgment as discussed in the paragraphs above is allowed) as BLTs at least twice, accounting for their contexts on both sides.

It is worth noting that as a consequence of the critical realist process of iterative abstraction, this ontological conceptualisation is arguably never truly finished, depending on any further empirical built environment complexes found or created. Each new empirical case may potentially cause revision or at worst refutation of the current ontology. There is virtually no explanatory value in presenting this process, due to the idiosyncratic way in which it takes place as a thought experiment. It suffices to say that from an initial ontologising attempt of six BLTs (erroneously pertaining to spaces more than their bounding) reconsiderations in dialogue with the empirical tests increased this number to the current thirteen, below captured in rather formulaic and repetitive expressions ensuring terminological precision. **Chapter 7** will demonstrate that these thirteen appear stable in two drastically divergent test cases, systematically leading to a full redescription of their built environment outline plans.

BLT definitions

Accepting the foregoing preamble of requirements, the following paragraphs will define and illustrate the thirteen BLTs (see **Table 5.1** below) that have resulted from a careful consideration of built environment outlines, from the vantage point of the operation of seclusion, starting with its simplest occurrence: the solid dominant. As mentioned in passing, the definitions are rather formulaic and repetitive, their complexity and long descriptions allowing for the precision and comparability needed to move beyond the contextual and conflated (lay) categories in which we tend to see the built environment (e.g. Lynch 1981; Sayer 1985, 2000; Mekking 2009). Yet, mereologically — *sensu* Husserlian metaphysical phenomenology: the parts constituent of the entity (cf. Varzi 2012) — the applied BLTs will still resemble the immediate perception of socio-cultural and (historically) learned or imposed entities and categories. After all, these entities and categories are usually a different order of (context specific) fiat understandings with reference to perceived bona fide objects. Where critical realism is said to be an ‘underlabourer’ of a research process (see Pratt 1995), in this context the ontology of BLTs could itself be seen as a socio-spatial underlabourer for investigations into the relations between the built environment and the society inhabiting it rather than an already all-encompassing, totalising, and prescriptive system for studying all its aspects. The BLTs themselves are open to revisions, adaptations, expansions, and additions. Moreover, as said above, alternative research aims could result in alternative conceptualisations, which could be used alongside this approach in complementary fashion, and correlations with other extant concepts and methodologies could inform insightful new research directions.

Nr.	Name	In figures	Nr.	Name	In figures
1	Closing boundaries	5.1; 5.2; 5.5; 5.6; 5.7; 5.9; 5.11; 5.12	8	Mutual boundaries	5.6; 5.9
2	Facing boundaries	5.1; 5.2; 5.6; 5.7; 5.12	9	Opening boundaries	5.7; 5.10; 5.12
3	Associative boundaries	5.1; 5.5; 5.8; 5.12	10	Neutral boundaries	5.8
4	Extended facing boundaries	5.1; 5.12	11	Man-made boundaries on unoccupiability	5.9; 5.10
5	Directing boundaries	5.1; 5.2; 5.3; 5.4; 5.7; 5.8; 5.10; 5.11; 5.12	12	Not man-made boundaries of unoccupiability	5.11
6	Disclosing boundaries	5.4	13	Not man-made negative boundaries	5.12
7	Enclosing boundaries	5.5	V	Virtual boundaries	5.2; 5.3; 5.7; 5.12

Table 5.1: Presentation of Boundary Line Type definitions (name, number, and figures)

Note that the BLTs have names (**Table 5.1**), where appropriate deliberately in active voice, so they better convey the processive (secluding) part of their materially present counterparts in the built environment, but for practical convenience also have numerals.

Closing Boundaries (1)

This BLT operates on the basis of seclusion from the surrounding configuration with the material property that the boundary is closable towards its outside. As the primary unit of the ontology, it does not contain further differentiation, making it a solid dominant.

Crossing the closing boundary from the outside secludes one from interactions within the surrounding boundary configuration and restricts interaction to participation with the socio-spatial system residing within the solid dominant. Crossing the closing boundary from the inside leads either immediately or indirectly towards increasing opportunities for interaction within open boundaries and opportunities to cross further boundaries.

An example of closing boundaries is best illustrated in **Fig. 5.1**, which depicts a house in its plot's context. Due to the reduction to outlines, this house is conveyed as a single cell, while the doorway (Type 2) is a specification of its relationship to the outside. In principle each building results as a solid dominant, Type 1. This includes apartment buildings and conjoined houses, where in the former the same entranceway(s) is (are) used to the outside environment, while in the latter the internal divisions result in separate buildings with separate entranceways to the outside environment (see also **Fig. 5.2**). Although it is not included in the ground level concern here, there is potential to expand the boundary conceptualisations to include affective internal architectural traits and full three-dimensional extents.

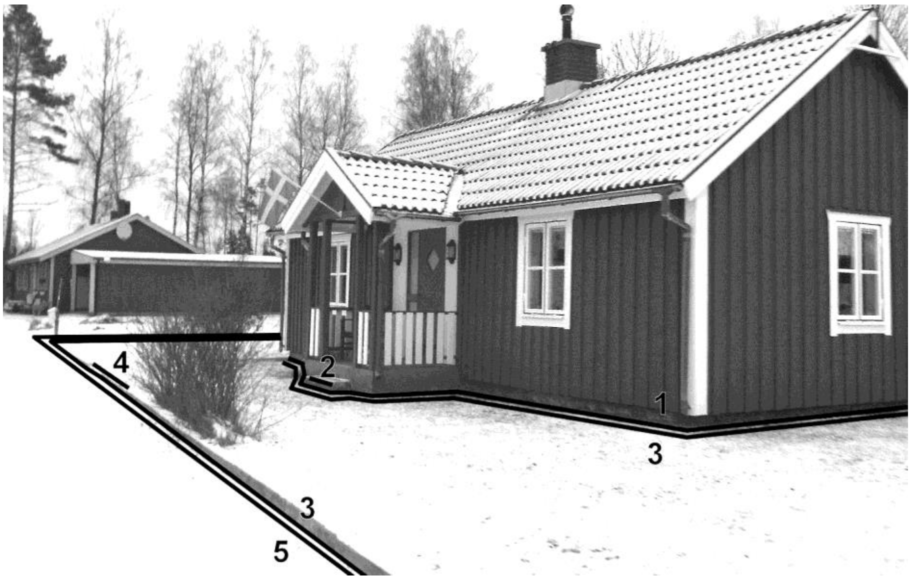

Fig. 5.1: BLTs 1, 2, 3, and 4 in context
Although some detail is inevitably obscured by the perspective in combination with 3-D objects, both Type 1 and 3 circumscribe the house, because the garden or plot envelops the outline of the house. Types 2 and 4's existence depend on Types 1 and 3 respectively, creating a specification of a part.

Facing Boundaries (2)

This BLT operates on the principle of orienting solicitation of interaction with a dominant from the surrounding configuration and the orientation from within a dominant towards interaction with its outside. Facing boundaries depend on the solid dominant created by Type 1 or the dominant created by Type 7. They consist of any place along a dominant boundary with material properties that are so constructed that, at will, it allows traversing or is stringently closed off. Multiple identifications of facing boundaries along single identifications of dominant types are possible and, therefore, so are multiple orientations. It is a prerequisite for any dominant to receive at least one facing boundary, to avoid a negative socio-spatial positioning in the inhabited built environment (see Type 11). By means of facing boundaries the residing socio-spatial system can be left to fulfil biological and social sustenance.

Crossing the facing boundary from the outside solicits interaction and participation with the socio-spatial system that constitutes the closing boundary and the extraction from the surrounding boundary configuration. Crossing the facing boundary from the inside leads either immediately or indirectly towards increasing opportunities for interaction within open boundaries and opportunities to cross further boundaries.

A facing boundary in its most usual form is illustrated in **Fig. 5.1**: a doorway into a house or building. Multiple orientations are possible through, e.g. back doors or multiple entrances in larger buildings such as offices. Facing boundaries can also occur on the basis of Type 7, for example as city gates in a city wall. Facing boundaries tend to represent formally constructed doorways and gateways, but not full architectural frontages or façades. It might be possible to discern a typology or hierarchy of facing boundaries in their own right (this could include functional, technical, cultural, symbolic, and economic factors). **Fig. 5.1**, for example, depicts a doorway into house with a porch, which could be seen as an additional spatial buffer or as semi-inside space. This research will refrain from engaging on such level of detail, but recognises the opportunity. Instead it is stressed that at least a single facing boundary is identified as appropriate and within set limits of certainty.

Associative Boundaries (3)

This BLT operates on the basis of dependence on a dominant it is directly associated with. Associative boundaries may occur in conjunction with additional associative boundaries with which it forms an adjoining configurative complex. Within such configurative complexes, associative boundaries may occur in successions, which could include Type 8 as well. In the absence of physical evidence for impermeable material properties, associative boundaries are assumed to be open. With physical evidence of impermeability associative boundaries can become dominants, which consequently extend the dominant they are associated with. Associative boundaries mediate the relationship between dominants and the surrounding boundary configuration.

Crossing associative boundaries from the outside indirectly leads to interaction with a dominant. Crossing associative boundaries from the inside creates opportunities for interaction within the surrounding boundary configuration.

Associative boundaries, as depicted in **Fig. 5.1**, we usually recognise as gardens (front and back) or plots associated with a building, but the emergent configurative complexes may include a combination of gardens and fields. Without precise and comprehensive knowledge, informed conjectures and expert judgments may be necessary to determine association. It is possible that cultural rules would go against what appears to be topologically dictated (e.g. a single lawn connecting to suburban houses, while there is an invisible legal boundary in the middle). Within the current context associative boundaries containing outbuildings, which could be seen as subsidiary solid dominants (introducing a hierarchical relation) to the dominant the associative boundary depends on, are simplified as internal organisation. For each study it can be decided whether to add such a level of complexity as appropriate and available data allows.

Extended Facing Boundaries (4)

This BLT operates on the principle of mutual orientation between any associated BLT identification and the surrounding configuration. It depends for its existence on Type 3 or Type 8 and needs to occur in direct connection (i.e. no further differentiations may interfere, necessitating a preceding crossing) to a Type 2 or several Type 2s. In instances of the latter the Type 2s belong to a subset of dominants, which each may have their own associated extended facing boundaries in a successive configurative complex involving Types 3 and 8. Extended facing boundaries may occur at any place along a boundary associated with a dominant that features material properties to accommodate unhindered crossings relative to the remainder of the type it depends on. Importantly, each Type 2 crossing leading into an associative boundary requires indirect connection (i.e. explicit permeable material properties) to the surrounding configuration on at least a single topological side[50] towards the surrounding environment not part of

[50] A topological side is defined as the occurrence of a continuous extent of a topological distinction of operating BLT identifications determining the socio-spatial description of a circumscribed space from its outside, which allows any form or shape to have distinct sides connecting to the surrounding built

the configurative complex of the dominant in question. As with Type 2, identifying multiple extending facing boundaries is possible on the basis of each Type 3 or 8. There is no requirement for the number of extended facing boundaries to concur with the number of Type 2s, as long as direct connection between them is allowed.

Crossing the extended facing boundary from the outside is a step of soliciting interaction and participation with the socio-spatial system that constitutes the mediation of the associated boundary towards a (solid) dominant or subset of solid dominants. Crossing the extended facing boundary from the inside immediately creates opportunities for interaction within open boundaries and leads towards opportunities for further boundary crossings within the surrounding boundary configuration.

In **Fig. 5.1**, we find the expected entranceway into the garden on the street side only very faintly determined by a shallow pathway leading up to the house. This situation suggests that extended facing boundaries can be very informal or even essentially cover all topological sides of a Type 3 or 8. In contrast, everything is possible, from vegetation, elaborate gated walls, and white picket fences. Informed conjecture or expert judgment may be necessary to identify extended facing boundaries. The essentially mutual orientation of the surrounding configuration with the configurative complex of a dominant or subset can be used as circumstantial evidence to designate a topological side as the expected location of an extended facing boundary (e.g. back garden and back alley providing access).

Directing Boundaries (5)

This BLT operates on the basis that it directs interaction along opportunities for further boundary crossings, into other socio-spatial systems. The direction of this BLT is enforced by its occurrence in parallels within the configuration. Directing boundaries may connect to a multitude of different BLTs in any number, and form any configurative complex through aggregation.

Crossing this boundary from the outside exposes one to immediate interaction opportunities originating from beyond any other boundary crossing and creates immediate opportunities for further boundary crossings. Crossing this boundary from the inside solicits interaction with socio-spatial systems constituting other types of boundaries.

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environment. That is, the full side of the house connected to the front or back garden is a topological side. Chapter 8 places this in context with further definitions of the BLT data structure.

As transpires from **Fig. 5.2**, directing boundaries generally pertain to streets and pathways. While the street network is an essential part of the urban built environment analyses of space syntax (e.g. Hillier 2007) and urban morphology (e.g. Conzen 1960), the definition here refrains from a direct definition of either a network or a formally constructed street. In this way, also more informally and often less geometrically constructed built environments can be better understood and described in terms of structure of the flows through the configuration. For example, Maya cities are usually found to feature few formal streets despite the construction of extensive urban landscapes (e.g. Barnhart 2003).

Fig. 5.2: BLT 5 in context
A typical urban street scene represents a clearly delimited directing boundary, in sharp contrast to adjoining buildings with doorways directly coming out into a street section, which ends in a virtual boundary with the crossing.

Directing boundaries have a clear correlation to ‘virtual boundaries’ (in analytical practice and representation (e.g. **Chapter 9**) a V in front of the BLT number concerned marks the distinction). This is an additional abstract construct to allow directing boundaries, as well as other types when appropriate, to circumscribe continuous surface areas. Where any of the parallel lines determining a directing boundary ceases to exist in a materially constant surface, a virtual boundary on that opposite end is gained. This is a virtual extension of empirical differentiation, without requiring actual material differentiation (e.g. a dead end street) for both parallels to connect to a configurationally different BLT (e.g. a street becoming a square). Note that this means that directing boundaries can be intermitted by non-directional areas (e.g. the central area of crossings and junctions), which result exclusively from such virtual boundaries.

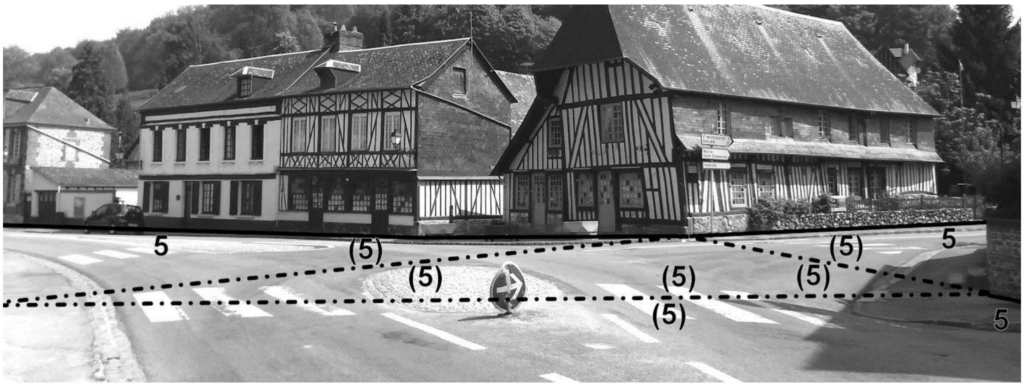

Fig. 5.3: Virtual boundaries of BLT 5
In this T-junction three streets conjoin, meaning three directing boundaries receive a virtual end, while a materially constant triangular central area emerges from the virtual boundaries.

Non-directional areas are not bounded spaces, but implicit continuations of any of the directing boundaries. **Fig. 5.3** demonstrates such a situation. Because virtual boundaries then only connect several directing boundaries, no interactional change occurs so the directing boundaries' operation will be conceived as continuous. In this way, the directing boundaries involved maintain their directing operation based on the same principles, but a choice of directions is enabled. Note that where Types 2 and 4 are openings with a materially continuous surface on either side, their existence is implied by a similar principle of virtuality.

Disclosing Boundaries (6)

This BLT operates on the basis of guiding interaction towards opportunities for further boundary crossings in multiple directions rather than a single particular direction (Type 5). Disclosing boundaries are integrated in the configuration by mutual orientation (guiding inside-out and outside-in crossings), giving it a sense of local centrality. Through the centrality of its connections it discloses various opportunities for further boundary crossings. These can occur in any number and form, but must include immediate or indirect (through Type 3) opportunities to solicit interaction with multiple dominants. In addition, it should be connected in at least one instance to a boundary that is not forming a dominant or the configurative complex associated with a dominant or any negative boundary constituted by unoccupiability (Types 11 and 12). This ensures its boundaries can be reached, and may involve virtual boundaries (see Type 5). The centrality can be recognised from the configurative context of the connections it discloses. In addition it offers the opportunity to act as a thoroughfare in connection with Types 5 and 9.

Crossing this boundary from the outside exposes one to immediate interaction opportunities originating from beyond any other boundary crossing and creates immediate opportunities for further boundary crossings, including several leading towards increasing opportunities to solicit interaction with dominants. Crossing this boundary from the inside solicits interaction with socio-spatial systems constituting other types of boundaries or leads to opportunities for further boundary crossings while exposing one to immediate interaction opportunities originating from beyond any other boundary crossing.

Disclosing boundaries usually pertain to squares and plazas in urban settings (see **Fig. 5.4**). These can occur in a wide variety of guises. When street space (informally) circumscribes a square, which is even the case to some extent in **Fig. 5.4**, though largely obscured from view, the designation of the disclosing boundary may incorporate these and it offers itself the opportunity for thoroughfare. When Types 5 completely circumscribe a central area materially, see Type 9.

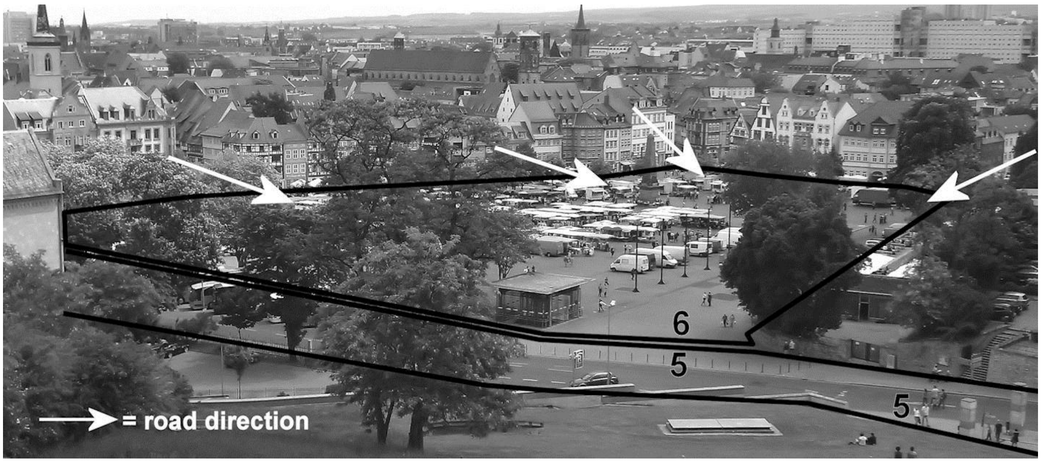

Fig. 5.4: BLT 6 in context
Despite various aspects of this complex city square being obscured in this view, the various streets opening up the square are visible, giving it a central local position, while it can just be discerned that multiple solid dominants are associated with it also.

Enclosing Boundaries (7)

This BLT operates on the basis of seclusion from the surrounding configuration with the material property that the boundary can be closed off towards its outside, making it a dominant. However, enclosing boundaries do not form solids as they circumscribe several other boundaries, forming an enclosed configurative complex or subset. Enclosing boundaries can occur at various scales and seclude a wide variety of BLT combinations. Importantly, an enclosing boundary that only encompasses a subset of solid dominants and their configurative complexes implies the existence of a mutual boundary (Type 8) for the interconnectedness of this subset on the inside. Consequently, if an enclosure of a subset cannot be closed off, Type 8 is implied.

Crossing the enclosing boundary line from the outside secludes one from interactions within the surrounding boundary configuration, but creates interaction opportunities within the configurative complex. Crossing the enclosing boundary from the inside leads either immediately or indirectly towards increasing opportunities for interaction within open boundaries and opportunities to cross further boundaries.

Enclosing boundaries are most readily perceived as city walls (see **Fig. 5.5**), which operate on a large scale. In their most stringent and sometimes intended form, city walls really delimit the entire built environment of a place, leaving only access routes on the outside. More typically though, especially in contemporary settings, cities have grown beyond their defences. In **Fig. 5.5** this can be recognised by the Type 3 on the right, which belongs to a building (solid dominant) leaning against the wall on the extramural side. On a smaller scale one can think of gated communities, which more or less box in a subset of buildings extracting them from the surrounding environment.

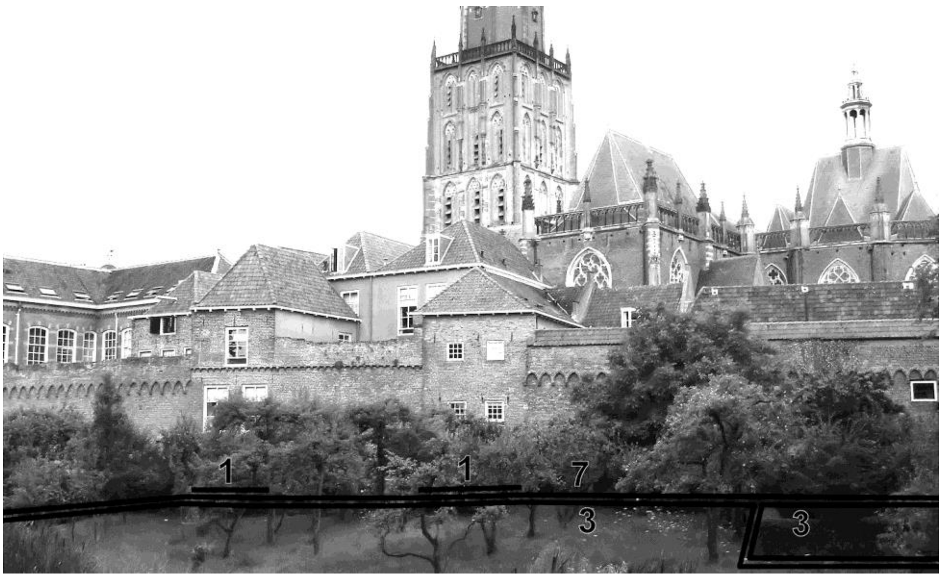

Fig. 5.5: BLT 7 in context
This city wall enclosed the old town. The orchard is placed in an associative area, while it is also noted that two solid dominants (Type 1, which is equally closable) form part of this enclosing boundary.

Mutual Boundaries (8)

This BLT operates on the principle that it is simultaneously associated with or encompassing a thereby distinct subset of several (solid) dominants (and any associated boundaries), forming a configurative complex with possible successions involving Type 3s. They mediate and interconnect these (solid) dominants contiguously, without further differentiation between them for access and soliciting interaction nor favouring orientation. Mutual boundaries may envelop a subset of (solid) dominants without the material property of impermeability (see Type 7). Alternatively they occur lateral to several (solid) dominants, deceptively akin Type 3 on an amalgamating level. When a laterally positioned mutual boundary creates a dominant through the necessary evidence for the contiguous extension of the impermeability of a subset of solid dominants and any associated boundaries (in the fashion shown in **Fig. 5.5**), the emerging circumscribing outline becomes a Type 7, while an open interconnecting outline on the side remains as a mutual boundary.

Crossing mutual boundaries from the outside leads to a position where one is oriented to indirectly interact with a subset of (solid) dominants and the possibility to solicit interaction with any one (solid) dominant within that subset occurs. Crossing mutual boundaries from the inside constitutes either access to or soliciting interaction with any of the (solid) dominants in the subset or to leave the position of indirect interaction with a subset for a position that exposes one to immediate interaction opportunities originating from beyond any other boundary crossing, and may create opportunities for further boundary crossings.

Mutual boundaries refer to the open arrangements between, and around, the buildings adjacent to secluding courtyards (see **Fig. 5.6**), cul-de-sacs, galleries, and more loosely placed groups of buildings (see **Fig. 5.9**), similar to farmsteads, etc. This implies that Type 7 is often associated with a Type 8 to describe the arrangement from the inside. Their mutuality means that they are constituted from the inside primarily by a socio-spatial system of interaction originating between the subset of dominants concerned. That is to say, the neighbours necessarily are condemned to closely knit relations, whilst maintaining a mutual extraction towards the outside. Indeed, the sign in the foreground of **Fig. 5.6** reads: ‘Private area, please do not roam.’

Fig. 5.6: BLT 8 in context
This inner courtyard is connected to the surrounding configuration from behind the photograph's view, interconnecting a configuration of several houses.

Opening Boundaries (9)

This BLT operates on the principle that it creates open, accessible connections towards its outside, while being an integrated, accessible part of the configuration from the outside. This integration in principle, however, does not entail specific orientations towards interaction opportunities with the surrounding configuration. This means that, contrary to Types 6 and 8, opening boundaries do not orientate or guide towards opportunities to solicit interaction with dominants. Opening boundaries do not require any *condicio sine quibus non* (particular boundary connections), although they may connect to multiple different BLTs, including dominants.[51] Opening boundaries with the material property of impermeability, like other open boundaries, should feature predominant mitigation for access. Opening boundaries can never be truly closable, because if they would they would become solid dominants (Type 1). Inviting crossings from the outside largely determines its residing socio-spatial system. In addition, opening boundaries may allow thoroughfare, forming through wayfaring in connection with Types 5 and 9.

[51] Opening boundaries may seemingly circumscribe dominants, while maintaining an indifferent (nonspecific) relation. Usually it can be assumed securely that such dominants do not distinguish a socio-spatial system, because they are part of internal design or functional specification, and therefore excluded from the current ontology based on outlines (e.g. follies in parks). If this is not the case, chances are we have a building with an estate, having some orientation to its outside. Making such distinction may depend on, background knowledge, informed assumptions or expert judgment.

Fig. 5.7: BLT 9 in context
This small urban park or garden shows how the boundaries maintain a very open and integrated relation to the outside, with the streets proffering thoroughfare an effective alternative, though the opening boundary offers a similar opportunity.

Crossing this boundary from the outside exposes one to immediate interaction opportunities originating from beyond any other boundary crossing, and may create opportunities for further boundary crossings. Crossing this boundary from the inside would also expose one to immediate interaction opportunities originating from beyond any other boundary crossing, but may include interaction opportunities with socio-spatial systems constituting other types of boundaries.

Opening boundaries have arguably the most protean of definitions, which confirms the various informal real world spaces they evoke. Of those spaces parks, like the one depicted in **Fig. 5.7**, are arguably the most formalised. Next to this there are areas which are simply used to flow through, multi-purpose areas, and many cases of urban fallow, but also agricultural and horticultural fields. **Fig. 5.12** shows a kind of opening boundary, which has the particular connotation of a cemetery.

Neutral Boundaries (10)

This BLT operates on the principle of neutrality, which results from ambiguity and the absence of single association to a residing socio-spatial system. Neutral boundaries remain as partitions that are fully incorporated in the built environment after all preceding (Types 1–9) BLTs have been identified by the researcher, depending on surrounding boundaries for their form. Neutral boundaries are not actively constituted by a single residing socio-spatial system on the inside (*non sequitur*), but result from boundary constitutions on its outside.[52] Its definition from the inside is therefore ambiguous. It may connect to various different boundaries without *condiciones sine quibus non* (particular boundary connections).

Crossing this boundary from either outside or inside does not change the opportunities for interaction when connected to non-dominant boundaries. But, crossing this boundary from the inside traversing into a dominant or associative boundary implicates (in)direct soliciting interaction with the dominant. Vice versa, crossing this boundary from a dominant or associative outside exposes one to immediate interaction opportunities originating from beyond any other boundary crossing and indirectly creates opportunities for further boundary crossings.

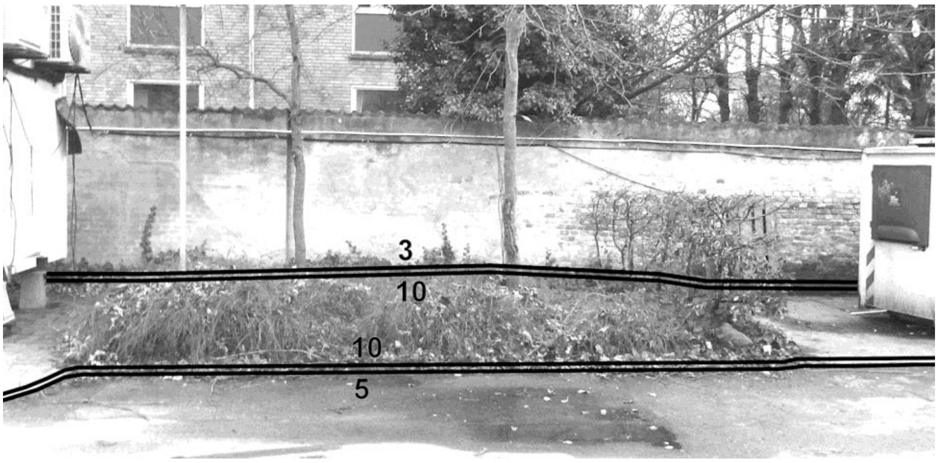

Fig. 5.8: BLT 10 in context
Alongside the road, this area is distinct and not part of getting one from space to space, but neither does it pertain to a particular single residing socio-spatial system.

In some cases neutral boundaries may also be associated with urban fallow (cf. Type 9), but more usually one should think of flower beds and areas of no particular social use, but rather functional use (e.g. storage in public space). **Fig. 5.8** shows some sort of combination thereof, although in this case it is not possible to enter from the Type 3 behind. Neutral boundaries are retained as integrated parts of the boundary configuration, but are not defined by a claim of any particular residing socio-spatial system. Instead, they act as neutral, non-associative, intermediates between other BLTs and informally extend the socio-spatial constitution of other non-dominant BLTs. In **Fig. 5.8** it is the street space (Type 5) that is informally extended.

[52] Here I would like to remind the reader how this is similar to the conceptualisation of (physical) holes in Smith & Varzi's (2000; Smith 2001; see Chapter 4) discussion of fiat and bona fide boundaries, because holes are determined by the boundary lines of the surrounding elements and do not contain their own shape. Such definition from the outside is inevitably part of Type 11 also.

Negative Definitions

The remaining three types of this ontology are based on the principle of negativity. They restrict the boundary configuration by not being constituted by any residing socio-spatial system, nor having an ambiguous relation to interaction complexes (cf. Type 10). Although they are connected to boundaries constituted by socio-spatial systems, these boundaries do not actively participate themselves in the socio-spatial significance of the built environment. This is either because they have not been built (see **Chapter 3** on primordial space), or they represent the edge of space that is unoccupiable; a physical impossibility to inhabit with a degree of permanence. Occurrences of not man-made boundaries eventually determine the maximum extent of the boundary configuration, while unoccupiability does not necessarily affect the continuity of this extent on the ground surface.

Man-Made Boundaries of Unoccupiability (11)

This BLT operates on the basis of negativity (*non sequitur* socio-spatial systems). Unoccupiable ground surfaces mean that no socio-spatial system of interaction can take place.[53] Crossing from either side is only enabled after physical changes are made to the material properties of the surface. For this boundary this is caused by human building processes.

There are two main examples of this thinkable. **Fig. 5.9** shows a railway. Though hypothetically occupiable, and indeed for someone interested in taking a built boundary approach to transport systems (e.g. an intercity approach) arguably of interest, formal and stringent motorways, railways, etc. form barriers on the contiguous local scale within a built environment. Within this realm one can also think of more static, inaccessible structures, such as electrical transformers. The more unequivocal occurrences of man-made unoccupiability, like steep slopes and waterways, canals, moats or ponds, are depicted in **Fig. 5.10**.

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[53] In rare cases unoccupiability could be caused by atmospheric conditions resulting from human actions, such as nuclear disasters, and even natural disasters, such as volcanic eruptions, and therefore not exclusively relate to the ground surface.

Fig. 5.9: BLT 11 in context: a railway
This railway is clearly fenced off from the outside, creating a barrier except for points of arrival and departure. The old mill alongside it creates the loose arrangements of buildings interconnected by a Type 8.

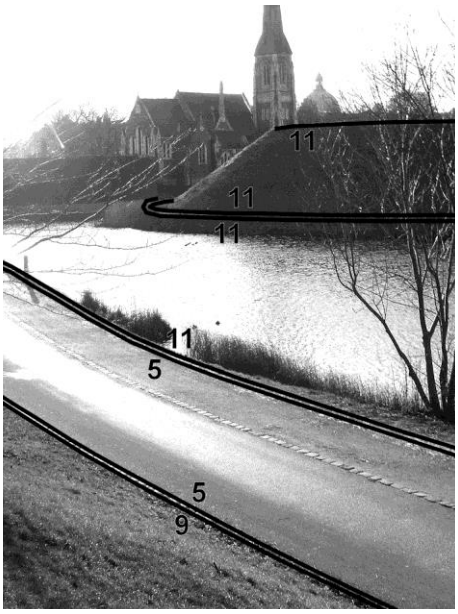

Fig. 5.10: BLT 11 in context: slope and water
The old defences of the fortifications in this photograph create two distinct areas that are unoccupiable: a steep slope and a moat.

Not Man-Made Boundaries of Unoccupiability (12)

This BLT operates on the basis of negativity (*non sequitur* socio-spatial systems). Unoccupiable (ground level) surfaces mean that no socio-spatial system can take place there. Crossing from either side is only enabled after physical changes are made to the material properties of the surface. For this boundary this is caused by nonhuman processes.[54]

Estuaries and the sea, especially where connected to a settlement such as the example in **Fig. 5.11**, are clear instances of how this BLT intersects, truncates or delimits the contiguous areal extent of the built environment. Many alternative (natural) examples can be thought of: big boulders, rugged mountain tops, rivers, marshes and impenetrable dense vegetation.

Fig. 5.11: BLT 12 in context
This quay shows where the city meets the estuary and the built environment is discontinued.

Not Man-Made Negative Boundaries (13)

This BLT operates on the basis of negativity (*non sequitur* socio-spatial systems). The boundary configuration complex outside of this boundary is not primarily oriented towards it, but may be organised to spill into it. Crossing this boundary from the outside leads to occupation within a spatial situation predominantly formed by nonhuman

[54] Unocupiability indicates that the surface cannot be inhabited or structurally utilised by a residing socio-spatial system. Note, however, that in certain cases bodies of water are deliberately maintained to function as access ways (e.g. Venice) and steep slopes might be made tractable by gondola lifts, etc. If suggestive physical evidence is found and the surface is rendered occupiable, other boundary line types could apply.

processes. Crossing this boundary from the inside either solicits interaction with socio-spatial systems residing within other types of boundaries, which may expose one to immediate interaction opportunities originating from beyond any other boundary crossing or are within the confines of configurative complexes resulting from dominant boundaries.

Not man-made negative boundaries are the natural ends of the built environment, simply referring to any kind of non-cultivated land or wilderness. Even in the example depicted in **Fig. 5.12**, closer inspection might reveal partitioning of land in grazing areas, etc. In its purest form, however, these boundaries may perhaps contain human traces, but no complete bounded spaces until one reaches another patch of built environment again. True wilderness in much of the heavily settled world is rare, but this construct can also be used to delimited datasets and areas arbitrarily for any case research or to simply describe smaller regions of limited human developments.

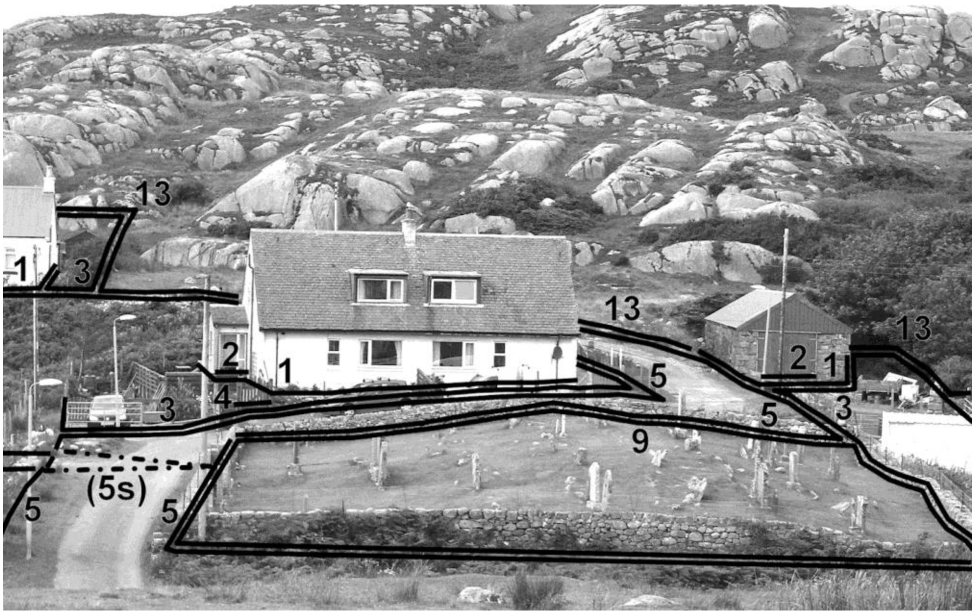

Fig. 5.12: BLT 13 in context
This view clearly demonstrates how a contiguously built environment is delimited by occupiable hills in the background, which are not constructed by human building activities. It also reveals the cemetery as a particular kind of Type 9.

Levels of socio-spatial significance of BLTs

Since an ontology in the critical realist sense consists of abstract causative concepts, imposing an ontology onto the world is necessarily an interpretive act. As explained at the beginning of this chapter, the ontology presented here is not a full metaphysical ontology, as it does not determine the relations of its constituent concepts to each other. Despite (or thanks to) this limitation we have now attained the ability to ontologically redescribe and provide an alternative visualisation of the urban built environment complex by applying or mapping the BLTs. However, gaining a more profound understanding of their socio-spatial significance as they occur in ontological relations to each other conveying the inhabited urban built environment requires a thorough appreciation of the contextual relevance of the theory which has informed their formulation. Since it was also recognised above that as abstract concepts no single BLT actually exists and can fully convey the empirical social reality of the material presence of a boundary in the inhabited built environment, it should be clear that only through investigating the interrelational positions in which BLTs occur, can genuine interpretation take place. Taking the entire morphologically and topologically composed BLT complex of an urban built environment, one renders *the ontology intrinsic to a city*[55], i.e. its *socio-spatial signature of inhabitation*.

From arguments in both **Chapter 4** and the current chapter it has been established that the way boundaries seclude contains their socio-spatial significance. Due to the metaphysically partial nature of this ontology, the ontological primacy of the operation of seclusion does not necessarily lead to relations of ontological dependence between BLTs. That is to say, there is no prerequisite of all BLTs that the preceding BLTs exist, starting with closing boundaries, for them to occur. Rather, the generic relation to the strongest secluding boundary, the closing boundary, is lineal or genealogical. The socio-spatial interpretive value of seclusion resulted directly from the way the inhabited built environment has been conceptualised in the theoretical framework presented in **Chapter 3**, but here this interpretive value can be further specified in terms of contextual relations. This will in turn inform interpretive efforts springing from imposing the BLT ontology onto urban built environments as presented in **Chapters 7-9**.

The socio-spatial significance of each BLT can be relationally and contextually understood in terms of three levels or incremental spheres, which are not mutually exclusive. That is, all three levels will be relevant and operational indistinctly at all times in all BLTs. These three levels can be formulated concisely and cogently as follows:

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[55] In the sense of the process oriented and practice based working definition of the city provided in Chapter 1.

A. Dimensional context: boundaries are personally territorial in that they create distances (densities) and spatial extents (size) and are introduced by the interpersonal and project activity process of distance setting.
B. Locational context: boundaries regulate relationally the restricting and enabling conditions affording and affecting our emplaced opportunities and ability to interact, which restricts and enables the accessibility to time-space resources, developmental negotiations, and the choices for project participation (activities and services).
C. Aggregative context: boundaries create entities and thus the coherence within entities on an incrementally fluid scale through their relational placement. These incremental entities enter inhabitants into necessary relations of dependence based on their adherence to context within both inhabiting experience and the constitutive development of aggregate patterns, causing knowledge of entities and a sense of familiarity from ideationally conceiving these.

All these levels are both effectuated and affected by morphological shaping as well as topological relations. While these formulations in themselves contain the core of socio-spatially relational significance between the BLTs as derived from their application, one should note that these relate back directly to the theoretical framework presented in **Chapter 3** and should thus be understood in this light. The three scales organise the socio-spatial significance of the material presence of the built environment according to how it accommodates and facilitates the constitutive interactional process of inhabitation.

The dimensional context refers back to the principles of proxemics (Hall 1959, 1968). This ethologically based study on interpersonal distance setting in a great variety of activities and situations searched for cultural differences in human territoriality. As argued in **Chapter 3** any (social) interaction is necessarily spatial and therefore involves a location and the distance between the constituent parts of the interaction. Through a personal territory one preserves a distance towards those constituent parts (e.g. people in encounter) which feels and is functionally appropriate or comfortable. The subdivisions composed by boundaries inherently distance one space from another. Their material properties further qualify and mediate the privacy and severity of that distance between neighbouring spaces.

Locational context refers back to the time-geographical and systems theoretical premises (see especially Hägerstrand 1975; Pred 1977, 1981, 1984; Thrift & Pred 1981;

Thrift 1983) of the life-path and project participation, which is tied to an ordering and qualification of interaction opportunities afforded by the built environment for movement and accessibility to time-space, natural, social, and subsistence resources. It concerns access to interaction opportunities and exchange through boundary crossing, the openness and closability of which are characterised by how their material properties restrict and enable crossing. The interrelational accessibility of any location is a negotiated compromise of the operation of seclusion. As follows from the negatively defined BLTs, relative accessibility is a requirement for all spatial subdivisions to partake in the socio-spatial complex of any inhabited (urban) built environment. Moreover, people require a minimum access to resources (including obtained through social relations) for subsistence.

Aggregative context refers to the very flexible and malleable shapes and scales in which entities and patterns can occur which are bounded towards their outsides on an aggregating level.[56] This is most readily connected with how we come to know and familiarise ourselves with the world. This applies to experiential knowledge, a sense of place, and biography formation (cf. Pred 1984, 1986), but also to the effects of imposed or formalised learned and acculturated social categories (cf. Sayer's (1985) layman's terms). These aspects of inhabitation mean that all BLTs are always placed in contextual relation to several variably scaled entities which we know about and/or experience (e.g. home, street, neighbourhood, district, city, region, nation, etc.), through which they influence the interaction processes of inhabitation and built environment development. Despite being volatile and flexible, it could be expected that the larger the scale of aggregation, the more people and built boundary investments will partake in any pattern, so the more rigid or persistent it might prove to be (see Jones 2010, quoted above), even if that is only by incorporating the greatest possible diversity within an area of a dataset. It expresses how in inhabitation people always are associated with and adhere to multiple entities and patterns of socio-spatial coherence and thus encounter boundaries against and as constituents of those contexts. The material properties qualify the kind of coherence that exists within aggregates.

The levels of socio-spatial significance elucidate how built boundaries continuously let individuals establish a personal position and situation in space, allow them purpose

[56] As part of an exploratory and experimental research process it is thinkable that a researcher might simply want to predetermine an area over which the pattern of boundary line type occurrence is assessed or project and impose preconceptualised entities from external definitions to the same end. The levels of socio-spatial significance discussed here guide the interpretation and synthesis of boundary line types on the basis of their endogenous logic.

when being in space, and let them be somewhere (a place) in space. If one would rephrase the three levels in a pragmatic way the socio-spatial significance referred to contributes to answering the following three basic questions respectively:

A. How do boundaries come about?
B. What do boundaries do?
C. Wherein are boundaries situated?

Note, however, that the 'when' question is not asked. The presence of built boundaries at any point in time is a necessary requirement of their material nature, while it is contingent upon the historical moment selected for spatial-material data collection or mapping whether the boundary appears. That is not to say that the contexts, conditions, and properties of the duration or endurance of boundaries are not significant for the interpretation of built environment data. On the contrary, through time the rhythms and patterns of development processes, change, and the weight and characteristics of boundary persistence or perseverance of patterns can be revealed, which all provide a temporal context respective of the time-slice data available to the levels of socio-spatial significance and nature of seclusion. Comparatively time then contributes to the creation of time-space specific socio-spatial signature of cities and reveals potentially shared characteristics of development. Rather than for redescribed individual boundary line segments, it is expected that a temporal view and analysis provides the best insights for entities and aggregates. In any case, computational analytical measures (see **Chapter 8**) can help the interpretive process of the highly complex resultant data across space and through time.

Towards practice

On the basis of the BLT definitions and their incorporated levels of socio-spatial significance, research on case studies is now essentially enabled. To better appreciate the position of a research method operationalising these BLTs and provide a broader support for the applied practices and conduct this requires, it should be declared here that this is not the only potentially comparative method for studying the urban built environment. Providing a methodological research context, the next chapter will briefly and critically review the most prominent methodologies currently practiced. After this, in **Chapter 7**, the empirical operationalisation of BLTs will be demonstrated as they are applied to two test cases of strongly contrasting urban traditions and diverging mapping sources. In practice, mapping BLTs will be demonstrated to share various traits with several of the existing methods discussed in **Chapter 6** and shown to be adaptable to a variety of built environment research data. Yet, its epistemological nature and aims are both significantly different as well as diversely complementary to existing knowledge production.

CHAPTER 6 – REVIEWING PREVALENT URBAN FORM AND CONFIGURATION METHODS

Introduction

Any new method for studying urban form and the built environment in particular cannot stand in isolation. Attention to the topography of cities has been part of academic discourse in Germany since the late 19th century (see Rietschel 1897; Whitehand 1981a), while Geddes (1915), who was influenced by the currency of evolutionary thought in biology, made important contributions to the architectural planning aspects of the development of cities in the UK and is credited for introducing the term conurbation. It is difficult to precisely trace the development of the study of urban topography and the morphographic approach to plans of city layouts, which was mainly practiced in Germany and reviewed with a rich bibliography by Whitehand (1981a). According to Whitehand, 'topographically conscious urban history' gained firmer footing during the interbellum (through the work of e.g. Rörig 1928; Hamm 1932). After the war this area of urban history grew swiftly (cf. Keyser 1969) and formed the basis for the morphogenetic approach (see Whitehand 1981a; Whitehand & Larkham 1992a), which is now the predominant kind of urban morphology, also referred to specifically as Conzenian urban morphology (after M.R.G. Conzen, see below). The specific focus of this research is not served by reproducing a comprehensive historical overview. Reviews by Whitehand (1981a), Stoob (1985), Slater (1996), and Rutte (2008) for the practice of preparing atlases of historic towns[57], and for urban history in particular by Denecke (1988) and Dennis & Prince (1988), all explain the respective disciplinary backdrops against which (urban historical) interests in the built form of cities could develop research practices (also see e.g. Dyos 1968; Fraser & Sutcliffe 1983, for edited volumes exemplifying various urban historical approaches).

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[57] The research practices discussed in this chapter often use the word town rather than city. Not all languages differentiate between village/town/city (see Clarke & Simms 1985). Town can be more flexible, because it is not tied to administrative city status. In this research the term city is used throughout, but town and city are seen as interchangeable words to refer to urban places, according to the definition laid down in Chapter 1.

This chapter is both broader and narrower in scope. In **Chapter 1** it was already mentioned that the boundary approach followed in this research will be reified by using Geographical Information System (GIS) software. Vector based GIS data offers the appropriate data format and functional flexibility for geographically representative line features, such as BLTs. Given the importance of GIS, this chapter will first give consideration to the relation between GIS and urban (social) history as a branch of the quickly developing field of historical GIS. This section will include a consideration of historically reconstructed plans, which form a promising data source for diachronic applications of BLT mapping. Finally the potential of using the analytical power of GIS data structures for studying urban form historically will be discussed through a recently developed data ontology. Having set the scene in which the GIS operationalisation of BLT mapping is embedded, this chapter will discuss the two predominant methodologies for studying urban form. In historical order, first urban morphology is reviewed, which is thematically related to the historical approaches preceding it in this chapter. Then space syntax will be reviewed, which is conceptually a closer match to the social scientific aims pursued in this study and a computational set of measures that is still very much being developed.

While (urban) historical GIS demonstrates the well-known ability of GIS software to compile, order, and visualise (historical) spatial data (see Gregory & Ell 2007), various analytical ideas put forward in this research, especially **Chapter 8**, have been strengthened by taking inspiration from urban morphological and space syntactic work. Since all these approaches share that they are based on mappable and geographically anchored information, this chapter will conclude with discussing some grounds for integration in GIS, using each method's merits. While the boundary approach operationalisation is significantly aided by the processes of data treatment in urban history and urban morphology, even before computation, analytically it stands to gain much from born digital GIS, space syntax computing and the quantitative potential of morphological measures. However, BLT mapping is not devised to implement integration, but complements extant methodological aims and exploits some of the technological and data advancements made. Conducting these reviews, this chapter provides the foundation for **Chapter 7**'s empirical operationalisation and **Chapter 8**'s explication of social analytical potential.

Considering methods for studying urban built form

Positioning this research amongst other methods preemptively transforms it from a mainly conceptual treatise into a mapping practice and analytical operationalisation. Although the mapping practice does not inherently require computation, a digital environment will improve its utility. By preparing BLT data in digital form the BLT information becomes a versatile dataset for visualisation advancing its rich formal redescriptive potential (cf. **Chapter 5**), but also paves the way for navigating the complexity of urban contexts by enabling additional geocomputational opportunities. Critical reviewing of related methods stimulates appreciation for the innate abilities offered by a GIS interface to systematically prepare, generate, and structure BLT data. Further, parsing the processes proper to this project is improved by elucidating similar aspects and terminology that have been developed in historically reconstructive mapping, urban morphology, and space syntax, despite the differences in grounding and purpose that render these extant methods unsuitable for the understanding pursued through boundaries.

Importantly the critique of these methods will not only focus on how they sustain their claimed purposes, but also to what extent they may support comparative research commensurate with the disciplinary foundation of this project. The lack of a consensus in approaches to urbanism to sustain appropriately long term comparative research has already been commented on in **Chapter 1** (Smith 2009b, 2012; Yoffee 2009; Fletcher 2010); similarly approaches to urban form have made reference to this apparent gap in concepts and arguments over the decades and lamented disparate research efforts (e.g. Clarke & Simms 1985; Whitehand & Larkham 1992a; Tilly 1996; Conzen 2004). Between urban morphology and space syntax, as two prevalent methodological strands for the study of urban form, the lack of integration has been noted as another gap preventing comprehensive understanding (Kropf 2009; Pinho & Oliveira 2009a; Whitehand 2010a, 2010b; Griffiths et al. 2010). Although this dissatisfaction is presented with an acknowledgement of the benefits of integration, this is a field that remains underexploited. Therefore, when reporting on the call for methodological integration it will be recognised that BLT mapping does not add to the current disparity. Instead, as shown in **Chapter 7**'s examples, it explicitly maintains the opportunities to combine and imbue its data and some of its analytical possibilities with ideas residing in extant methods. Yet, it is not purported that BLT mapping directly serves or advances this integrative agenda.

While it could easily be argued that quantification and (associated) computation are necessarily comparative and comparable methods, it should be stressed that using quantitative measures is not intrinsically interpretable in a meaningful way. "A GIS system […] is a tool, a point of departure for comprehensive analysis rather than a scientific result in itself." (Kalmring 2012: 259) So when, like Kalmring (2012), assembling and compiling information into a GIS, this recording and documenting practice still tends to adhere to what the tool prescribes. For proper study and analysis it is necessary to go beyond the tool and the application of the tool as a method. Instead, I find quantitative research should devise a method which fully incorporates theoretically informed concepts formulated to comprehend the phenomenon under scrutiny (**Chapter 3-5**). Tools can be used or designed to operationalise the concepts in analyses appropriate for the questions asked. GIS software is not inherently neutral and one should ensure that the way conceptual information is stored and conveyed suits the understanding one has and the associated analysis one desires. Putting qualitative data in a GIS does not spontaneously invest the tool with qualitative powers of its own.[58] Hence, the boundary methodology ensures that the *qualitative* use *of the tool in aid of interpretation is comparative also, not just its computational underpinnings and its quantitative output*, which often substitutes ordering and objectification for understanding.

Urban historical GIS

Historical GIS for cities

In **Chapters 4** and **5** it transpired that the study of inhabited urban built environments based on boundary concepts relies on surveyed and mapped evidence, whilst leading itself to a mapping practice. GIS software has become the new standard

[58] The computational basis of GIS requires empirically measured (quantified) data entries. In recent years concerns have been raised on the positivist and reductionist perception this causes amongst qualitative researchers and how to advance the qualitative or critical non-empirical use of GIS (e.g. Kwan & Schwanen 2009). It is acknowledged that the quantitative nature of GIS, despite its limitations (see Leszczynski 2009), does not prevent its use for qualitative purposes and approaches that are sensitive to societal complexity, diversity, and becoming. In archaeology McEwan & Millican (2012), Gillings (2012), and Hacıgüzeller (2012), all within the space of a single, year have published on the need and opportunities to push GIS approaches further with proper theorising and ontologies, phenomenological sensitivity, understandings of affordance, and non-representational thought. Through this research some initial steps are offered for making progress by following such approach in studying the inhabited urban built environment, aiming to avoid the 'black box' effect in employing the technology (cf. Griffiths 2013).

in draughting maps and plans, storing mapped and generally spatial data, and adds a spatial database and statistical analytical powers to its mapping abilities. While already a popular research and applied tool of geographical, planning and archaeological disciplines, recent years have seen a distinct rise in the use of GIS for the historical study of cities. This development is part of what could be called a 'spatial turn' in the humanities (see Griffiths 2013), which complements the 'spatial turn' in the social sciences from the 1980s. In history this has led to the rise in popularity of the use of GIS in a variety of research practices (e.g. Gregory & Ell 2007; Lünen & Travis 2013). Increasingly there also is attention for the built environment, seeking integration with archaeological applications of GIS (attested by the volume of Paliou et al. forthcoming *Spatial Analysis and Social Spaces*).

Historical interest in (urban) space is primarily guided by the Lefebvrian (1991) sense of imaged and socially produced space (Arnade et al. 2002; Griffiths 2013). As discussed at length in **Chapter 1**, considerable deep historical interest in cities has been directed at their origin and definition. Consequently, social and economic generative factors of settlement patterns have been emphasised. Much historical work in the twentieth century retained the focus on the market as the generator of cities, taking after the influential meta-theoretical ideas of Marx and Weber (Arnade et al. 2002). These ideas attempted to characterise the historiography of the urban in terms of what the city is, what it is used for and what it is understood to be. The influential and essentially economic 'central place theory' of Christaller (1933) subsequently concentrated attention on city networks and city regions, both in urban geography (Parr 2005, 2007; Meijers 2007) and deeper history (e.g. Verbruggen 2007; Brughmans et al. 2012). The discipline of history has had little attention for how urban space within cities functions. Griffiths (2013: 154) argues that history's foci on the study of maps as cultural objects and historical space as representation have "created something of an epistemological blind spot for historians wishing to access and substantively describe 'spaces of practice' produced by everyday activity."

Space in the discipline of history used to be reduced to a meta-narrative (Arnade et al. 2002), but when history shifted its interest to space it did so on grounds provided by critical and cultural human geography, usually stressing Lefebvrian metaphorical and representational concepts of space on top of geographical locations, i.e. social notions and actions with spatial implications going beyond passive 'container space'. Historians may have especially been susceptible to Lefebvre's (1991) theses, because he attended to pre-modern cities in his work. Arnade et al. (2002) argue that the multivalence of space in the abstract notions of Lefebvre provided more concrete grounds to investigate historically produced space, because it connected "'the material' and 'the discursive,' the physical and the ideological, or the experienced and the imagined. Lefebvre insisted that social space is produced and exists at each of these registers." (Arnade et al. 2002: 522) Yet, examples within the same journal issue (e.g. Estabrook 2002; Boone 2002), demonstrate that the empirical concreteness and theoretical sophistication on the basis of which an interpretive role for space is claimed, is found on highly interpretive levels and within particular socio-cultural contexts (see **Chapter 1**), while the empirical specificity of the material presence of space remains largely neglected. This leads to conflated historical concepts of space, because the presupposition that certain spaces are ritual, political, legal, cultural, etc. means research in predetermined contexts postdicts their existence and only characterises them in that social interpretive context.

While readings of produced and represented urban space cannot be reduced to the purely material (Arnade et al. 2002), it is argued in this research that the socio-spatially significant role of space for human inhabitation can only be understood through accepting the material nature of its construction and empirical presence. Historians' spatial dimension is at odds with this view, because their source material might be locational (or contain geographical references), but is very rarely inherently spatial. Consequently, it is not the spatial properties and development that are studied, but the events that happened in space. This is demonstrated by historical GIS efforts: historians, like human geographers (see Jones et al. 2009), usually map to spatially visualise what happened where and investigate resultant locational relations. The urban application of the broader emerging practice of historical GIS is taking advantage of the flexibility in data collation and integration offered by an environment founded on digital databases over draughting plans on paper (Lilley n.d.). Despite GIS's geostatistical and geoanalytical underpinnings, historical GIS is aimed foremost at locating historical sources, data, and events on a map to visualise them in spatial distributions, which may help explain historical processes and relations (see Gregory & Ell 2007). Placing historical events and sources in urban space, however, inevitably relates them to locations and situations within a built environment, the specificity of the physical properties of which increases opportunities to use GIS in an analytically productive way beyond illustrations and maps.

Urban examples of historical digital mapping practices show a preference for on the one hand locating the past on historical plans, and on the other placing historical city plans in relation to the current city plan by using (semitransparent) overlays (e.g. Frank

2013; *Locating London's Past* (undated); *Tokyo Cityscape* (Amherst College, 2009); *Paris Cityscape* (Amherst College, 2010); Jensen & Keyes 2003). Jensen & Keyes (2003) offer a good example of the spatially more intricate practice of locating sources, people, and events onto a visualisation of the city plan in a specified historical period (19th century). They successfully demonstrate the possibility of applying a GIS approach on an intra-urban level.

With the aid of historical maps and archives they derive a city plan of Aarhus, Denmark[59] that forms the basis for their historical GIS. They emphasise that such a reconstructed map is only one of many possible interpretations of the source material, which reminds us that no map can represent the only truth (**Chapter 5**), but follows an (interpretative/research) agenda (e.g. Lilley 2012, Hutson 2012, Beisaw & Gibb 2013). The plots of which the reconstructed plan consists are invested with information on people (and their occupation) and property (tenure), creating a multi-linked database. Despite the intricate information spatially compiled, Jensen & Keyes' (2003) study also illustrates the spatial limitation of the current historical GIS applications. Eventually their GIS is primarily used for the visualisation of distribution patterns of e.g. the wealth and occupation of its residents. In this sense their method provides little more than a progressive scatter plot directly linked to a transparently grounded representation of actual physical spatial organisation (i.e. social notions with spatial locations). The implication is that historically specific information is analysed against a map *background*, but the historicity of the physical space itself is not studied (Griffiths 2013). It enables the authors to interpret in a spatial dimension with analogies to ideas on accessibility and centrality, without engaging in the creation of an understanding of such spatial (and material) properties and their development. Imposing social information onto space by locating it is not the same as understanding the constitutive role of space.

This is not to say that the researchers are insensitive to the dynamics and change within urban space, "rather we see it as [corrig.] something dynamic and constantly being contested and renegotiated between the inhabitants." (Jensen & Keyes 2003: 11) Frank (2013) shows an even richer GIS and a desire to address the intricacies of urban life, but in reality does not move beyond the essential limitations of placing history in

[59] This derivation conveys most credible cartographic representation of urban space on a specified level of detail. Jensen & Keyes (2003) limited themselves to using the 1870 register map as a basis, which is then cleared from irrelevant features and adjusted with reconstructed features from textual historical sources: the 1801 population census and the 1801 fire register (which contained all buildings). No physical empirical data is used.

space. The *Cityscapes* (Amherst College 2009, 2010) mentioned above demonstrate the potential of visual comparisons between time-periods by using GIS' native ability to overlay city plans (the Amherst Mapping Application (*aMapApp3*) was used to develop these examples). From this we can conclude that current urban historical GIS mainly utilises the opportunities to compile, collate, store, link, and visualise historically sourced or derived information in selective spatial contexts. It does not perform a social study of urban space, interpreting the space itself in a social and temporal sense. In social scientific urban historical geography and archaeology one would want to ask: '*how* was the spatial structure and situation where something happened?' instead of just '*where* did something happen?' Both questions are part of studying the relationships between society and space, which according to Griffiths (2013) is one of the main reasons for historical science to engage with the geographical practice and theory of GIS.

At the convergence of urban geography and urban history, however, there are a number of volumes that demonstrate examples of historical research that engage with the nature of urban space in more intricate ways: *The Study of Urban History* (Dyos 1968); *The Urban Landscape* (Whitehand 1981b); *The Pursuit of Urban History* (Fraser & Sutcliffe 1983); *Urban Historical Geography* (Denecke & Shaw 1988); *The Built Form of Western Cities* (Slater 1990); *Urban Landscapes* (Whitehand & Larkham 1992b).[60] Although (prehistoric and classical) archaeology and ancient history are still virtually absent in these books, they offer somewhat of a balance to Lilley's (2011b) otherwise justified alarm over historical geography's neglect of the medieval and Jones' (2004) emphasis on the benefits of extending human geography's temporal frame of reference beyond the recent past. As follows from the nature of empirical evidence for cities in the ancient past, the endurance of the physicality of the built environment (Harris & Smith 2011) explains its pivotal place in research here and clarifies the important contribution made by archaeology (Clarke & Simms 1985). Questioning the socio-spatial significance of the material presence of boundaries would thus prepare the historical fields for uncovering the entanglement of living in the material-spatial world over the long term.

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[60] Most volumes have affiliations with urban morphology (discussed below), especially *The Urban Landscape* and *Urban Landscapes*, which are edited by urban morphologists, and are more geographical than would be expected of history in general. *Urban Historical Geography* offers arguably the most diverse overview of the field. Chapter 1 presented some of this discourse within a different disciplinary purpose.

GIS aided historically reconstructed city plans

Despite its spatial shortcomings, what is paramount in the discussion above is the inescapable fact that a historical situation of a city needs to be mapped both for the usual historical GIS applications as well as the boundary approach. While in historical GIS this is often achieved by simply digitising and/or vectorising historical maps, there is a tradition of work in which a plan for the city is more progressively reconstructed. This practice predates accessible GIS software. On the one hand side there is the so-called 'cross-section method' (see Bisschops 2012) inspired by Keene (1985; Keene & Harding 1987). This approach allows series of properties to be mapped with reasonable accuracy, while anchoring incidental properties or buildings within each sequence of properties (cf. the notion of plot series, Conzen 1960). Bisschops (2012) points out that his research uses both the 'cross-section method' and historically intensive regressive mapping. Regressive sequence mapping on the basis of urban plans is derived from urban morphology (discussed below). Lilley (2000, 2011a; Lilley et al. 2007) is the strongest advocate of this approach. In regressive sequence mapping, urban morphology helps to create a skeletal plan for earlier phases of a city often on the basis of the first accurate urban plans from the 19th century. Advanced critical historical and archaeological methods are needed to flesh out the process of working backwards in time, producing a comprehensive mapping of the city (Lilley 2011a; Dean 2012a, 2012b). As demonstrated through their work, the comparative compilation and matching of information has much to gain from GIS technology.

In addition to historical and archaeological data, comprehensive cartographic reconstruction requires the careful and critical historical conjecturing of missing features (see Lilley 2011a), a data creation practice made more easily accessible by GIS. Only by employing this composite method can the resulting map approximate a complete and reasonably accurate snapshot representing the town at a specified historical moment. This plan is then used to geographically locate and position (social) historical sources to the spatial shapes and references created, which again are now greatly aided by the data management technology within GIS. So far, and to my knowledge, this practice has only been developed within western European historical contexts until the (high) medieval period.[61] This means that for work in that area, the reconstructed plans resultant from regressive sequence mapping of urban layouts form a

[61] Frank's (2013) Rio de Janeiro is an exception, but is of western colonial origin and little more than a historically critical digitisation.

methodological prerequisite for the analytical socio-spatial mapping presented in the **Chapter 7**, especially where ongoing cities inhibit large extents of archaeological mapping.

It is not one of the aims of my research to add improvements or even a full-fledged example of this mapping practice. As Dean (2012a, 2012b) shows, archaeology may uncover significant flaws in urban morphologically reasoned map regression, making accurate attempts at reconstructing city plans comprehensively an immensely labour intensive and complex project. Consequently, many urban historical GIS projects have not been primarily concerned with such reconstructions of the urban built environment, again confining themselves to more recent periods for which reasonably accurate maps exist. *Mapping Medieval Chester* (Faulkner n.d.); *Mapping Medieval Townscapes* (Lilley et al. 2005); *Pompeii Bibliography and Mapping Project* (Poehler n.d.); *Alpage* (Noizet & Costa n.d.; Noizet & Grosso 2011) and the GIS for medieval Antwerp (Bisschops 2012) are excellent examples of the meticulously detailed reconstructed plans that can be achieved using digital tools, opening up promising future directions for social and spatial research such as proposed by this research. The Winchester test case introduced in **Chapter 7** is based on Keene's (1985) exclusively historical work (archaeological data was not consistently used in the preparations of the town plans) to contrast with the research practice on the basis of archaeological surveys of material remains (Chunchucmil). Nevertheless, in both data situations, the preparation of the basic spatial layout data for a specific historical moment of a town's development relies on historically critical reconstructive and conjectural mapping efforts.

GIS-based approach to studying urban built form

Perhaps unsurprisingly, not historians or geographers, but archaeologists and conservationists have been developing a GIS-based approach specifically aimed at furthering the study of urban built form. Lefebvre, Rodier, and Saligny (Lefebvre at al. 2008; Lefebvre 2009; Rodier et al. 2009; Lefebvre 2012) have been building a conceptual ordering of the urban fabric that emphasises temporal dynamics and function for storing and analysing urban archaeological information. The underlying theoretical model this is based on is referred to as OH_FET and the idea of temporal geographical information systems (essentially a simultaneously temporal and spatial database) (Peuquet 1994, 2001). Their practice is based on a conceptual model hierarchically composed of simple and (aggregate) complex objects elucidating the intricate becoming and use of architectural complexes in an urban setting (Lefebvre et al. 2008; Lefebvre 2012). It focuses on eliciting the historical rhythms of built space in development.

Following Galinié et al. (2004), the method is based on accepting the assertion that any understanding of the dynamics of urban fabric over time necessitates the conceptualisation of a constituent object of the urban fabric which culminates all knowledge about its transformations. This gives rise to the 'historical object', an initial interpretation relying on analogies with other information, meeting three fundamental criteria: 1) location and surface area (where is it?); 2) date, duration, and chronology (when did it exist?); 3) function, social use, or an interpretation (what is it?) (Lefebvre et al. 2008; Lefebvre 2009; Rodier et al. 2009). Lefebvre (2009) explains that any modification of these three criteria causes the disappearance and creation of a new historical object or interpretation. Theoretically this is a logical consequence of the aggregate complexity of historical objects and not dissimilar to the logic that any change produces a new atomic situation for the entirety of a city (see **Chapter 4**). It should be noted that this methodological endeavour includes more information sets than the material-spatial data used for the boundary approach in this project. In contrast to the constitutive and experiential emphasis in this research, the ultimate goal of studying the urban fabric through OH_FET entails understanding the dynamics of the formation of urban space. To that end, detailed temporal information is the driving force for generating analytical spatial units, while it remains unclear what the meaning of these features is.

The conservationist might welcome this method, because it separates spatial locations according to how often they changed spatially and/or functionally (a chronographic representation)[62], for example, but overlooks that in social empirical reality any change changes the whole occupation of the urban locus. Making temporal information the driving factor instead of its socio-spatial understanding of how things occur to us and play a constitutive role in our inhabitation of the world inevitably leads to poorly conceived and conflated social use types (*sensu* Lynch 1981) in Lefebvre's (2009) and Rodier et al.'s (2009) discussion of their model. They combine established socio-cultural interpretations (cf. **Chapter 1**), which exist only in time-space specific cases and could additionally be dependent on particular historical periods. This will naturally preclude broad comparative application. Another problem is the desire to treat

[62] This practice bears some resemblance to the more complex hierarchical outcomes of morphogenetic analysis, determining the persistence, or morphogenetic priority, of form complexes (below) (see Conzen 1988, 2004).

temporal intricacy on a similar level as spatial complexity, as this would require equal information across the whole urban space for each unique moment of (spatial or functional) transformation. This introduces a laudable pursuit of a research aim privileging temporal dynamics over the more conventional time-slice or snapshot approach, yet this approach overlooks that such equal information is rarely available and therefore introduces either conceptual anachronisms or conceals necessary extrapolations.

Lefebvre (2009: 1) insightfully criticises time-slices and periodisation (cf. Mekking 2009) as "broken down a priori, either in an abstract manner and by century, or on the basis of specific periods in the political history of the town. This breakdown prevents any specific research into the temporality of the town and its own rhythm of functioning." However, no matter how much effort we put into completing information throughout a place's history, we remain data dependent and in reality it is difficult to retrieve like-for-like detail across a large body of case studies. As previously declared in **Chapter 4**, taking urban space as a contiguous whole (locus) means that here the necessity of the atomic[63] assumption of mapped data is accepted, which means the diachronic aspect of the boundary approach relies on time-slices. These may be necessarily more coarse temporally speaking, but when applied critically will not allow the obscuring of historical reconstructive and conjecturing efforts in compiling a comprehensive urban plan for a historical moment. Because of this assumption, time-slices are inherently better suited for spatial analysis of the whole and thus the study of the process of inhabiting the urban built environment concerned.

In contrast, disaggregating complex historical objects into more temporally specific features by OH_FET logically makes such approach better suited for the intensive studies of smaller urban areas for which great amounts of historically detailed information is available throughout, as demonstrated by Lefebvre (2012). Working with reconstructed time-slice plans relieves one from integral dependence on equally detailed historical information throughout. This, however, does imply that per single diachronic case study, best practice would be to choose a historical moment for which the best consistent information is available or for which conjectures are equally justifiable across

[63] Assuming a time-slice is atomic explicates its momentary indivisible nature as a whole. A time-slice is an abstract entirety which is immediate and inseparable: no time passes, everything occurs at once. The assumption that a material presence extant in one time-slice that appears in a previous or succeeding one would be a continuation, is akin the everyday assumption that the house we live in and return to after absences is a continuation of the same. That does not withstand its relative position might have changed because of developments within any wholes (e.g. city) of which it is part.

the area as a whole (cf. Lilley n.d.; Keene's (1985) 1417 plan). Yet, as Lefebvre (2009) warns us, accepting the limitations of available data in this way could lead to a 'source effect' (bias) with regards to understanding temporal rhythms of development. Although I agree researchers should be aware of this, not even Lefebvre (2009, 2012) overcomes organisation on a temporal scale (in years and periodic ranges) and periodic historical differences in availability of information judging from his own chronographic representations. Depending on the research aims one might opt to strive for the same historical moment across cases. This second option would naturally make the historical period significant as a research objective.

Although within the boundary approach thus pursued some historical and temporal detail of development is likely to be lost, in comparison to OH_FET, its constitutive theoretical basis ensures a temporally sensitive basis of interpretation, the understanding of which is perhaps less historical than it is part of the socio-spatial *processes* of inhabitation. Despite some conceptual confusions and unclarities, it can be conceded that OH_FET has definite merits over a boundary approach where understanding temporality on the micro-scale is essential or archaeological and historical documentation of locations through time is concerned. In this sense, with OH_FET we return to the historically invested locations of historical GIS and are still shorthanded for analysis of a material record on urban built environments on a spatial, especially socio-spatial, and comparative level.

Urban morphology

Background to the method

Rather than a single method, urban morphology is often seen as an overarching term for all research on urban built form. "The study of urban morphology is concerned with the description and explanation of the form, development and diversity of urban areas." (Kropf 1993: 212) Explaining the process of formation is usually the central tenet. When referring to urban morphology as a method, what is usually meant is the morphogenetic approach of Conzenian urban morphology (specifically town plan analysis) after the German founder of its most influential branch, M.R.G. Conzen, who was influenced by the German morphographic and urban topographic studies of the first half of the twentieth century (Whitehand 1981a, 2001). Since 1994 urban morphological interests have been united in the International Seminar of Urban Form (ISUF), which hosts an annual conference and publishes the journal *Urban Morphology*.

In an attempt to determine their identity, ISUF president Moudon (1997) traced the origins of urban morphology back to three schools of thought: German (Conzenian), French (Versailles), and Italian (Muratori and Caniggia). Nonetheless, the leverage of such ideas was carried wider, which makes the combined origin of the current mix of ideas difficult to pinpoint (see e.g. Larkham (2006) for an overview of the specifically British study of urban form). Whitehand (2007) mentions that the seminal work of Mumford (1961) on the historical development of cities was also of significance. Keith Lilley (2000: 7) posits current urban morphology as derived from a commonality between the work of the influential scholars Conzen, Hoskins, and Beresford, explaining “they shared an interest in understanding the physical development of medieval towns and they shared a common belief that the histories of medieval towns could be written using modern maps, coupled with aerial photographs and field work.”

The French school at Versailles was originally influenced by Muratorian urban morphology and has since lost a coherent presence, with both strands displaying more architectural underpinnings than Conzenian urban morphology. Muratorian urban morphology is still practiced, in particular under the guidance of Cataldi and Maffei from Florence (e.g. Cataldi et al. 2002). It can be referred to as a ‘process typological’ approach in which a hierarchy of “elements, structures of elements, systems of structures, and organisms of systems” (Kropf 2009: 111) is formed starting from the materials of architectural construction for buildings and the buildings as elements building a hierarchy towards structures of urban tissues (Kropf 1993 provides a full discussion). This enables a study of the urban tissue on various levels, the elements always creating a whole within a context with increasing complexity theoretically *ad infinitum* (Kropf 1996). This can be compared to the structural logic in Conzen’s (2004: 123) morphogenesis: “It is an axiom of urban morphology that everywhere in the townscape the systematic form complexes are hierarchically nested in a physical sense.”

Note how this Muratorian ontology results from the constitution of form rather than a constitutive process (as in inhabitation). As established in **Chapters 4** and **5**, the operation of seclusion makes the built structure or building also the ontological starting point for the boundary approach, which itself in part can be used to uncover a city’s intrinsic aggregates. What I have called the ‘ontology intrinsic to a city’ (**Chapter 5**) could be compared to the organism of a town, which refers to the system of structures altogether (Kropf 2009). Importantly, in Muratorian urban morphology types are forms occurring at all levels of the hierarchy, which is not the way BLTs are formulated. Moreover, as a building is not conveyed by a single BLT (**Chapter 5**), the ontological starting point should not be equated with the process typology approach. While on an architectural level an interesting dialogue between BLTs and process typologies might occur, in this research's aim to devise an appropriate methodology as a practice, geographical Conzenian urban morphology is deemed more suitable.

As noted at the start of this chapter, Conzen's morphogenetic approach grew out of the German morphographic and urban topographic traditions (Whitehand 1981a). Due to Conzen's emigration to England his work could grow to wide acceptance as part of Anglophone discourse (Moudon 1997). The morphogenetic approach today is therefore mostly a German-British research tradition (Whitehand 2001). Rather than reproducing Moudon's genealogy of urban morphology as practiced by ISUF members, the methodological and analytical tenets of Conzenian urban morphology are of relevance here. It is generally agreed that previously unparallelled maturity and clarity of Conzen's ideas was reached in his 1960 *Alnwick, Northumberland: A Study in Town-Plan Analysis* (Whitehand 1981a). In this work his foundational ideas about the research process known as *town plan analysis* became properly and comprehensively grounded, its units and terms defined. In the morphogenetic approach the evolution or development, the origin and history, of the townscape (urban landscape) are traced. The idea of morphology in general helped shape the theory of evolution[64], relating the outside form of organisms to their internal structure and defined its relative constitutive parts (as also seen in archaeological typologies as well as Muratorian urban morphology; cf. Kropf 2009). Urban morphology, then, refers to the study of the historical development of built form and its spatial structure (cf. Gordon 1981; Kropf 1993). Within Conzen's (1960) study, it can be seen that from defining a pre-urban core (see Clarke & Simms 1985, for detail on this specific term) his approach is all about the historical explanation of the origins and the formation of urban form and building fabrics of a town.

[64] Recently architects Tang & Yang (2008) published a book titled *Urban Paleontology*, which contains an eponymous approach to the evolution of urban forms. Rather than urban morphology the authors connect their ideas directly to biology, archaeology, and geology, ignoring the considerable likeness in the basis of both approaches. Rather than reading town plans in terms of persistence of urban tissue, they excavate plans (reversing urban design) to conceptualise urban form in terms of urban fossils and species. Their aim is to understand the origin of urban forms to improve the planning and prediction of future urban developments. The somewhat forced analogies to palaeontology are interesting, but do reach the methodological rigour of urban morphology.

The principal premise for this is that a town's built environment is made up of an accumulation of traces of past activities. "The building or street, as a direct result of the act, can be taken to refer to the time in which it occurred. Buildings and streets are signs referring to particular events. The history of a town is thus written in its fabric." (Kropf 1996: 255) This gives way to the assertion that the history of cities can be read by means of their physical form (Moudon 1997), which is the basis for the method of town plan analysis (Conzen 1960). In recognition of the tremendously persistent nature of historical built form into current built environments, Lilley (2000: 7) says: "the form of streets and plots revealed on a large-scale plan of a given settlement provide in themselves clues about their origin and development." Upon studying the foundation of town plan analysis the phrase 'in themselves' seems misleading, as the practice relies heavily on the use of historical sources rather than urban form alone (see Conzen 1960, 1988[65]).[66]

In general it can be said that Conzen's (e.g. 1960, 2004) work aims to construct a comprehensive building and development history of a town. In this way the structure of the historical character of a town can be assessed (e.g. Kropf 1996). On this basis, urban morphology is often nowadays applied in planning studies and strategies to do with conservation of the townscape, growing awareness of the historical grain of cities[67] (see e.g. Whitehand 2007; Kropf 2011). This development towards the management of the townscape has grown over the years under the influence of Whitehand, as attested by contributions in Whitehand (1981b) and Whitehand & Larkham (1992b), although Samuels (2010) argues that its adaptation for historical conservation is not yet complete.

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[65] According to M.P. Conzen, M.R.G. Conzen did not give his consent to the version of the paper included in the 1988 volume. The original was eventually printed in the 2004 volume *Thinking about Urban Form*, which was also consulted for the references made to the 1988 publication.

[66] Similarly archaeological discourse displays a common belief that the built environment reflects the social organisation of its society. However, in reality this type of interpretation relies heavily on the use of analogies on the basis of ethnological sources (e.g. Carmack 1981; Hill & Monaghan 1987).

[67] Whitehand (2007) critiques architecture's and planning policy's limited focus on the historical grain allowing for a piecemeal of external aesthetics. Architectural design philosophies like Alexander's *The Timeless Way of Building* (1979) and *A Pattern Language* (Alexander et al. 1977) or Krier's *Urban Space* (1979; see Carmona et al. 2003 for further ideas) approach the urban built environment from the pre-existing buildings and arrangements we already know, to arrive at idiosyncratic normative theories championing planning methods that would lead to aesthetically pleasing and well-functioning designs. The seminal works of Kostof (1991, 1992) also used similar architectural complexes and socio-cultural divisions to construct his readings of urban form through history. These rarely take into account the constitutive elements of the historical grain of the city, but often have had a much larger public exposure to architects, planners and policy makers than the more academic approach of urban morphology (Lynch's (1960) popular analytical approach goes some way to alternative concepts).

Certainly, urban morphology is a field in motion, as Whitehand (2010b: 361) remarks: "the development of further specialities remains an integral part of the expansion of knowledge."

The practice of town plan analysis

Town plan analysis as a methodological practice has already been introduced above. It merits some further attention as aspects of its foundation influence predominant research practice on urban form, including the mapping of BLTs (see **Chapter 7**). The result of town plan analysis was to explicate and map the building history of the shape of a town based on historically and spatially coherent plan units (cf. Muratorian urban tissue), which are somewhat subjectively identified within (see Conzen 1960, 1968, 1981; Whitehand 1981a; Lilley 2000; Conzen 2004). While it thrives on incorporating large bodies of socio-economic historical sources and a degree of intuition to inform its urban mapping outcomes as a spatial representation thereof, this entanglement with historical particularities tampers with its comparative applicability. Town plan analysis structurally connects historical context (vs. discussion in **Chapter 1**) to the processes that shape urban space to create a townscape consisting of the following form categories: the town's plan, building fabric, and land utilisation.

Reading of the town plan in turn depends on an ontology of its composition, envisioned to consist of three elements (for a detailed discussion see Conzen 1960): "[...] streets and their mutual association in a street-system, the individual land parcels or plots and their aggregation in street-blocks with distinct block patterns, and the buildings or more precisely their block plans and the arrangement of these in the town plan as a whole" (Conzen 1968: 117). As the morphogenetic practice was based on historical as much as geographical practice, it typically does not go beyond the medieval period. This means that for all towns from that period onwards and the western or globalised world, this ontology holds comparative morphological merit. Indeed, versions of the basic division of elements have become a common influence in urban built environment research, and Conzen (2004) clearly had intended his ideas to travel even beyond European historic towns.

Logically, in order to conduct a town plan analysis, a town plan is required: a large scale map "showing essential detail of layout in recognisable and measurable form" (Conzen 1968: 115), which according to Conzen in practice is nothing greater than 1:5000. This permits one to see the block plans of individual buildings. Town plan refers to both the cartographic representation on a predetermined scale of the physical layout of a town and the physical layout of the plan itself. The latter means the town plan, together with the other two form categories of building fabric and land utilisation, are all three functionally and genetically connected in the townscape: *as a palimpsest rather than an accumulation*. Temporally the persistence of conservation decreases from townscape to building fabric to land utilisation (Conzen 1968). For the elements of the town plan, the street pattern, the plot and aggregate blocks, and the buildings and their block plans, this usually applies in reverse order.

On the basis of these characteristics, the researcher attempts to define plan units that display a sense of coherence in its historical and spatial development. Lilley (2000) clearly states this process is part subjective and therefore follows a strategy of validation[68], entailing the verification of drawn plan units with archaeological and historical evidence. Conzen (1968: 120) himself meagerly proffers:

> "[...] the recognition of distinct plan units is of great importance and can often illuminate the growth stages of a medieval town [...] when available written records fail to give any information. Such recognition depends on the careful scrutiny of plan detail such as the behaviour of street spaces and their bounding street lines, and the shape, size, orientation, and grouping of plots, all such evidence leading to the identification of the 'seams' along which the genetically significant plan units are knit together."

The behaviour and correlation that would give the method rigour remain unexplained.

It has become common practice for urban morphological and historically reconstructive town plan studies to use the first accurate historical plan of a town, usually the 19th century plan, on the basis of which a ground level base plan with the relevant features can be produced (see Conzen 1960; Keene 1985; Lilley 2000). Producing a base plan is a practice that is equally widespread amongst urban morphological methods, including space syntax and indeed used for mapping BLTs (see **Chapter 7**). Regressing through the historical origins of the built form of a town with town plan analysis may help create a skeletal plan for earlier phases of a town's

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[68] Although Lilley's (2000) practice is more critical of intuition, it still runs the risk of creating a research fallacy similar to cultural historical and culture area research in archaeology (Lyman et al. 1997; Vis 2009). Here colonial, geographical, or linguistic designations introduced biased boundaries around a people or region, the prevalence of which may seemingly be validated by research, because it forms the initial delimitation of analytical outcomes.

development and thus a basis for historically reconstructed city plans (see above). However, ultimately the analytical unit of town plan analysis itself (the plan unit) is a relatively coarse spatial reference, which cannot reconstruct a town's precursory phases in great detail. The subject of town plan analysis is recognition and comprehension of a town's structure in terms of its plan units (Conzen 1960, 1968). This intellectual position is elsewhere specified as follows:

> "[...] evolutionary plan analysis helps to recognize the geographical structure of urban built-up areas in terms of concepts covering recurrent morphological phenomena. Its pursuit requires an appreciation of underlying economic and social processes. It specializes in the town plan [and its elements in correlation] but links up with work on urban building fabric and land use, thus forming an integral part of the complete analysis of the townscape." (Conzen 1981: 53)

Emerging terms and processes

Practising town plan analysis sees the emergence of an array of urban morphological terms and processes. Conzen (2004) provides a relatively comprehensive glossary of these, making such effort here redundant. Together these terms provide a particular vocabulary which can logically describe the spatial processes of the development of urban built form. Although comprehensiveness is beyond reach here, some of the main terms convey processes that have the ability to be comparatively applied and elucidate urban development processes across the world. Whitehand & Larkham (1992a) for example recognise that *development cycles* and *fringe belts* are processes which have been successfully applied in divergent case studies. Nonetheless, Whitehand (2012) clearly identifies an underrepresentation of non-western case studies in urban morphology and argues that the lack of conceptual engagement in current research and the loss of an overarching view are impeding the all-important comparative agenda in urban morphological discourse (cf. Whitehand 2009).

In this context it is telling that the development cycle is specifically based on the *burgage*[69] cycle, which is actually based on a historically specific property arrangement not necessarily found in the same stringently framing way elsewhere or in different periods. Nonetheless the process of 'building repletion' on plots of land, involving:

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[69] A burgage refers to a burgage tenement, which typically comprises the property of the plot of a house with or without associated land that could be rented in medieval boroughs or towns.

initial institution of the plot, repletion (development), climax, and recession (disuse and fallow, completed by demolition, clearance, obliteration or transformation of plot for redevelopment) (Conzen 1960, 1968, 1981), may have wider bearings. Furthermore, Conzen's (1960) dissection of plots provides a nifty descriptive language for aspects of how its properties affect the built environment, such as: plot head, plot tail, plot dominant, plot accessories, plot series, street-line, building line, and building frontage. This allows logical constructions, like arguing that if the building line coincides with the plot head on the street line, rows or serried lines are formed which constitute closed building development.

On the basis of the (burgage) plot, quantitative measures could further enrich the morphological description and study, as standardised measures[70] of frontages can help retrieving the original measures of transformed plots (Conzen 1960; see also Lilley n.d.). Building repletion can be measured in density ratios (percentages) that mimic figure-void diagrams (see Trancik 1986), i.e. built solids vs. open space (Conzen 1981).[71] Measuring building coverage within the built environment has been developed for urban design purposes.[72] Measuring the dimensions and surface areas of plots and plots per area could help express the effects of plot pattern transformations[73] from intact to metamorphic, due to processes of truncation, absorption, or amalgamation. Although mapping BLTs does not necessarily inhibit these measures, that is not to say they are all intrinsically meaningful in terms of their socio-spatial significance (see **Chapter 8**).

Similarly, while fringe belts (inner and outer) have become recognised especially with relation to modern planning challenges such as the effects of ring roads (e.g. Whitehand 1977; Whitehand & Morton 2004; Conzen, M.P. 2009; Ünlü 2013), the process of *fixation lines*, which occur when urban growth (temporarily) comes to a halt, may have wider relevance. Fixation lines bring about distinctly patterned effects in the

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[70] Conzen (1960) acknowledges that measures could have a cap for the maximum width of a frontage due to environmental or technical (rather than social, economic or historical) restrictions and he also mentions the standardised measures could differ between building types.

[71] In Chapter 7 it will be demonstrated that the first stage of BLT mapping visually resembles a figure-ground plan, mapping out the built volumes from the open spaces.

[72] If building coverage is used as a measure for the intensity of land-use, the vertical rise of buildings needs to be taken into account. This is demonstrated by the GIS adaptation of this measure of Liu et al. (2010). Conzen (1981) places this issue at the analysis of building fabric and land-use rather than town-plan analysis, which covers building repletion.

[73] In cases where there are no previously instituted plots, the piecemeal building repletion of open or unstructured space is called transformative growth (Conzen 1960, 1968), with examples such as a market space being colonised by permanent building of stalls (cf. Rörig 1928; Lefebvre 2012).

further development of the town plan, which could include circumscribing roads, town walls, and irregularly shaped open areas. Fixation lines often mark distinct patterns of morphological development on either side (see Conzen 1960, 1968). In patterns of persistence of boundary lines and their inevitability as a social empirical presence as well as their aggregation into entities (**Chapter 5**), some of the logic of fixation lines and other seams between plan units may be replicated, while both kinds of analysis maintain the potential to operate at a variable resolution.

Even more generically, and related to the idea of transforming the physical properties of the world (see **Chapter 3**), earlier forms (pre-urban nuclei of either natural or man-made origin) act as *morphological frames* for the formation of subsequent built forms, which in turn can modify the frames. As such old field boundaries and country lanes may act as morphological frames for subsequent settling or expansions of towns. These shapes can become incorporated as e.g. streets in the layout of the plan (Conzen 1960). The influence of previous field systems on the development of urban form has already been recognised by Hoskins (1977) and seems to have been of major influence in Dutch cities as Leiden and Delft (Taverne 2008; Raue 1982). In transformative instead of additive changes some traces of earlier phases may be retained. These are *inherited outlines*, which act as morphological frames, while other shapes will be obliterated. Remaining traces from morphological metamorphoses are called residuals[74] (Conzen 1981).

In fact, from the above it is clear that although not explicitly its focus, Conzenian urban morphology features an abundance of references to boundaries. Plan units are delimited by seams, plots are delimited by plot boundaries, building lines indicate their extent, growth may stop in fixation lines, and morphological frames delimit confines of development or persist as residuals. Importantly, the difference with my research is that these have all been defined as spatial occurrences describing shapes and conceptualised within (historical) processes of formation and transformation. Ultimately urban morphology uses discrete surface areas as a spatial convention, although Conzen (1968: 117) recognises that all plan element complexes are interconnected and mutually condition each “other’s origins, physical relations, and functional significance, not just at present but in historical time.”

Urban morphological ‘boundaries’ are likely to be maintained in a boundary method as boundary lines (feature outlines) (see **Chapter 4**), but they do not directly

[74] Cf. Tang & Yang’s (2008) urban fossils.

concur in any way with the socio-spatially defined BLTs (**Chapter 5**). Conzenian urban morphology is interested in providing a socio-economic historical explanation of the emerging urban forms. In this sense it counters the trend where the study of architectural and urban form is usually not integrated in social and urban history (Tilly 1996). Within this historicism the interest in 'the social' (cf. **Chapter 2**), which includes the decision making processes by agents (*sensu* Sayer 1979; cf. Gordon 1981; Lilley et al. 2007), is subsumed in what can be known through a documentary background (especially Conzen 1988; see also Whitehand 1977). "[...] plan analysis properly includes the evaluation of physical conditions of site and situation as well as of relevant economic and social development. The latter, indeed, provides the background for the inter-dependence of plan, building fabric, and land use, and the bridge between the morphological and the functional approaches in urban geography." (Conzen 1960: 5) The social empirical reality of its bounded shapes is not regarded in terms of its social significance. Equally, morphological comparability is only ensured for the historically specific framing of the examples on which its practice was based.

Conzen (1988) makes some generic allusions towards the social utility of the town plan, where the street system as an access pattern is a long-term commitment of a whole urban community, while the social utility of the building fabric is the historically less constant commitment of the respective owners (vs. Mekking's (2009) ideas on representational architecture). Generally it applies that the more people involved, the more resistant form complexes become to change, so a building is likely to change more often than the street system. The social utility of the pattern of land utilisation is the provision of viable locations for each land-use unit, depending on the access pattern. Conzen (1988) also makes a fleeting remark that suggests that the shape of a town's morphological elements may impede internal communication and the ability to defend. None of this is structurally explored on the basis of the town's built layout. Yet, Lilley et al. (2007) show that urban morphology is a good aid for comparing urban planning designs, and the effects of individuals and authority on their realisation in roughly *ceteris paribus* situations. *En passant* he also confirms the abolition of the traditional planned versus unplanned dichotomy and their associated organic and geometric patterns[75] (cf. Smith 2007; Vis 2009), a remark Conzen (1968) already made on European medieval towns.

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[75] Following from the openness as asserted by complexity theory (Bentley & Maschner 2003) and the outcomes of interactions leading to 'unintended intentionalities' (Chapter 4, cf. Abbott 1995), the possibility already follows that geometrically regular patterns could also emerge from individual

In the posthumously published anthology *Thinking about Urban Form*, we find a short essay in which Conzen (2004) acknowledges that urban morphology is in needs of a sounder philosophical foundation, which according to him could be found in cognition theory and the cultural philosophy of Cassirer. Via this work connections to the phenomenological thought in my research and spatial cognition in space syntax (see below) could be made. Conzen reaches the insight that urban settlements are dynamic complexes in which the causality of the physical, biotic and social collides, which resonates much better with the social scientific foundations of the boundary approach. This does not withstand traditional urban morphology's formative effect on the methodological development of the study of BLTs as demonstrated in the subsequent chapters.

Space syntax

Background to the method

Space syntax finds its origins in the attempts during the 1970s to understand "the influence of architectural design on the existing social problems in many housing estates that were being built in the UK" (Pinho & Oliveira 2009a: 110). Its theoretical foundation reached cogent completion in Hillier & Hanson's (1984) seminal *The Social Logic of Space*. The general intention was to improve on planning practice and normative (or generative) architectural design, which lacked scientific grounding and produced built form that seemed to harbour the ingredients for detrimental effects by alienating its residents (Hillier & Hanson 1984; Hillier 2007; Marcus 2010). Hillier & Hanson (1984) propose a conceptual model in which space is a dimension of social life, yet their approach to studying built environment configurations is firmly connected to the quantitative tradition of the 1960s and 1970s (for morphological context, see Larkham 2006). According to Hillier (2005) this places space syntax somewhere between a phenomenological social scientific approach (e.g. Tuan 1977; Lefebvre 1991; Seamon n.d., 2012; and theoretically Griffiths & Quick 2005; this research) and a social physics or modelling approach (e.g. Batty & Longley 1994; Longley & Batty 2003; Bettencourt 2013; Brown & Witschey 2003; Brown et al. 2005; Volchenkov & Blanchard 2008; Wilson & Dearden 2011; Wilson 2012).

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development and settling activities (e.g. aligning houses and/or entrances with respect to their relative location).

According to Hanson (2012), the objective of the research reported on in *The Social Logic of Space* was to develop a new language for space, and each idea was extensively tested on a wide variety of the most challenging built form contexts. While Conzen's (1968) initial comparative ambition was to enable the study of most British towns, justifying his selection of a medieval starting point, space syntax explicitly wants to be comprehensively comparative (e.g. Carvalho & Penn 2004; Omer & Zafrir-Reuven 2010). To this end the terms used for concepts and analyses were kept predominantly abstract (Hanson 2012). Comparability is evidently aided by the quantitative basis of its methods. Consequently the outcomes of space syntactic analyses tend to be quantitative and accordingly visualised, after which they can be compared to real world observations. Against the backdrop of developing (by Alasdair Turner) its own suite of software, Depthmap, which is freely available and since 2011 also open source, the uptake of space syntax application and development has grown considerably.[76] This not only applies to academic research, but also industry and policy applications through its commercial branch (e.g. Chiaradia & Lemlij 2007; *Space Syntax Ltd.* (undated)[77]).

Space syntax is now probably the best known analytical approach to the study of ground plan built environment configurations and represents a theory and associated family of tools (Hillier & Hanson 1984; Hillier 2007; Bafna 2003; Van Nes in prep.). Moreover, in its very foundation, it makes substantial social scientific claims. Space syntax aims to contribute to the study of the man-environment paradigm and the relations between society and space at large (Griffiths & Quick 2005; Griffiths 2013), but does so by initial empirical reference to built form (cf. urban morphology) rather than its emergence. In a way the lengthy theoretical treatise that precedes the development of a methodology in this research project is exactly aimed at avoiding the apparent mismatch between space syntax's social theoretical claims and its operationalisation in empirical tools.

This mismatch is probably best explained by the structuralist thought that underlies space syntax's inception. Hillier & Hanson (1984) declare that part of their thought exercise was to install a corrective for the over-emphasis on social theory rather than spatial theory. "The primacy of configuration in the 'social logic' of space does not just happen to be the case. It originates in the logic of *space* itself." (Hillier et al. 1987: 363, emphasis added) So an imbalance became nested in space syntax's foundation where it

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[76] See the *Depthmap* (undated) website for full information.

[77] Space Syntax Ltd. is the commercial consulting company founded as a spin-off by the space syntax group at University College London, and showcases example projects on its website.

ended up being enthralled by capturing and elegantly reducing geometric complexity of spatial configurations into concepts for its study which are only tentatively connected to its social theoretical claims (see Griffiths & Quick 2005; Vis 2009; Van Nes in prep.). At the same time, despite being part of the core theoretically descriptive language used at the outset, temporality has been demonstrated to be a structurally neglected aspect in space syntax (see Griffiths 2011). Although space syntax analyses can become part of narratives of historical explanations (Griffiths 2009, 2011, 2012a; Thaler 2005), it offers itself no (historically) constitutive logic informing its analytical outcomes. As spatial analytical tools, the analysis always takes place on a synchronous level inhibiting systematic subsequent theorising or interpretive conduct (Griffiths 2011).

Finally, but perhaps most frequently, the theoretical foundation for space syntax and its analyses is criticised for pursuing cognitive argumentation without having a proper foundation of spatial cognition in place[78] (e.g. Bafna 2003; Penn 2003; Conroy Dalton et al. 2012). Hanson (2012) states that space syntax was built on a hypothesis test approach (contrary to critical realism, **Chapter 2**), and indeed its sustained practice correlates space syntactic measures with ethologically derived observations of social behaviour. As said before (**Chapter 1**), this research excludes a psychological line of argumentation, which forms the realm in which spatial cognition resides. Although the way we psychologically understand space and make decisions may ultimately explain all behaviour, obtaining complete psychological knowledge on all participating people in space is untenable. Without even a full-fledged cognitive theory in place, this cannot replace an overarching social view on the outcomes of actions.

In terms of positivist hypothesis testing, space syntax deals its hand when supposing that people have an innate ability to 'read' the arrangement of spatial layout (Hillier & Hanson 1984; Conroy Dalton et al. 2012). On this basis space syntax can start seeking law-like regularities between its topological measures and behaviour like way-finding (pedestrian movement) to uncover the possible rules according to which we understand configurations topologically (cf. Penn 2003). Except for the development of space syntactic viewsheds (isovists) (see Franz & Wiener 2008; Paliou & Knight 2010), there is no direct inclusion of human or social experiential concepts. Against its theoretical background, the cornerstones of space syntax are formed by spatially distinct convex spaces (conducive of co-presence in space) and axial (visual) lines (conducive to movement) and the poorly defined socially distinct visitors or strangers and inhabitants

[78] This is also an issue within the field of architectural communication theory (see Rapoport 1990; Smith 2011a). Applying experimental approaches (cf. Zacharias 1997) could help construct a theory.

of a place (Hillier & Hanson 1984). Although there is no denying the importance of our sense of vision nor movement and co-presence, none of these concepts necessarily came forth from a constitutive social framework.

Applying space syntactic concepts

In absence of a satisfying (social) theoretical grounding of space syntactic concepts and analytical measures, the analogy with the work presented here is best found in the very advanced ways in which space syntax enables the study of the topological structure of built environment configurations. A first distinction introduced in space syntax analysis is between the interior world (inside a building, gamma analysis[79]) and the exterior world (in a settlement, alpha analysis) (Hillier & Hanson 1984). This is a distinction that is maintained in this project as well. The urban scale naturally pertains to the exterior world, whereas the stringent seclusion (see **Chapter 5**) of a building, or indeed all major feature outlines, extracts the arbitrary internal arrangement of a socio-spatial system from negotiations with its outside. Both kinds of analysis depend on breaking up their configuration in its constituent parts, i.e. the fewest convex spaces, and the connections between them (in settlements conveyed by axial lines, which are a longest lines intersecting convex spaces connecting up the whole system with the fewest lines). Subsequently this can be plotted as a graph, which is justified (J-graph) from plotting it from a specified space or node (Hillier & Hanson 1984). The input for this operation is a ground level base plan featuring the built volumes of a town, which bears similarity to urban morphology and the requirements for applying BLTs (**Chapter 5**). Software can currently assist in the preparation of these conceptual building blocks, although Ostwaldt (2011) argues that the mathematics and theory behind the J-graph is poorly understood, leading to inconsistent interpretations.

Although the above analytical building blocks are clearly very abstract and comparative, from the theoretical grounding of BLTs it is also clear that they are socially unsatisfactory. While Hillier & Hanson (1984) assert that the analysis is topological and therefore not primarily interested in metric measurements, it is also clear that their conceptualisation of space entirely results from a geometric reasoning rather than a social argument. Surely, one could say that a *convex space* is socially significant because it allows for *co-presence* (of human beings), but the definition of the

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[79] Incidentally, in archaeology syntactic analyses of interior space are arguably yet more widespread than urban analyses (e.g. Fairclough 1992; Moore 1992; Cutting 2003; Fisher 2009).

convex space is only spatially derived.[80] Similarly *axial lines* may indeed hypothesise intervisibility, but they dramatically reduce the intricacies of built form and topography (e.g. Hohman-Vogrin 2006, on elevation). This reduced spatial representation leads us to the important realisation that rather than the physical properties of built form as it occurs to us, space syntax studies the structure of the representation that follows from their logic (Griffiths 2012b). Space syntax tools calculate probabilistically or rule based spatial patterns across 'open' space, as afforded by its configuration. It is this space syntactic pattern, as an abstraction derived from the simplification described instead of the original empirical (social) reality of the shape of the built environment configuration, which is analysed to produce an array of relational values (Hillier & Hanson 1984; Hillier et al. 1987; Bafna 2003; Batty & Rana 2004; Pinho & Oliveira 2009a; Van Nes in prep. present explanations and overviews).

Because space syntax focuses on topology and spatial relations[81], it tends to overlook the importance of dimensions and geography (Ostwaldt 2011), although recently after some critique (e.g. Teklenburg et al. 1993; Ratti 2004a, 2004b) metric measures are being combined in analyses (e.g. Van Nes & López 2007; Mavridou 2012; Van Nes in prep.). By applying the basic concepts of space syntax the actual characteristics of built spaces are lost, which is to say, the urban fabric (as in urban morphology), but more importantly the socially constitutive material differentiations created by built boundaries (**Chapter 4**) on which this research is based.[82] Through incorporating the *constitutedness* of streets (having a building entrance bordering its space) (Hillier & Hanson 1984), some built density characteristics of the sides of occupiable streets can still find their way into space syntax (e.g. Van Nes & López 2007) and further qualified (e.g. Palaiologou & Vaughan 2012). Still the relation between building and open space is only there in abstraction, without its socio-spatially significant material properties. Yet, this has not stopped space syntax from being applied for architectural analyses (see Hillier et al. 1987; Hanson 1989) and for creating

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[80] The theoretical arguments presented in Chapters 3 and 5 prioritise not co-presence, but occupiability of space and indirect social interaction on the basis of materialisations.

[81] Note that Hillier et al. (1987: 363) distinguish spatial relations (between two spaces) from spatial configuration which considers "at least, the relation of two spaces taking into account a third, and, at most, […] the relations among spaces in a complex taking into account all other spaces in the complex."

[82] Following Ostwaldt's (2011: 449) discussion, space syntax actually disregards most aspects of (architectural) form, as with its space shaping contours "a building delineates both the space it contains (its interior) and, to a lesser extent, the space in which it is contained (its site or context)."

typologies and classifications of urban form and land-use patterns on its basis (e.g. Jiang 2007; Wagner 2008).

In the modern and planning related cases in which space syntax is generally applied, its analytical outcomes tend to be correlated with social and economic observations in current city life. In this way the aforementioned measures become connected to how configurative properties of the built environment afford (through permeability, connectivity, accessibility, and movement in general (Bafna 2003; Pinho & Oliveira 2009a)) the occurrence of lively or less lively streets, which in turn represent indicators for economic viability (e.g. Chiaradia et al. 2008; Narvaez et al. 2012; Griffiths et al. 2010; Valente 2012). Because the probability of liveliness is associated with the cognitive readability or intelligibility of space for way-finding argued to be tied to global and local integration measures (Van Nes in prep.), this is again where the lack of cognitive theory is felt, which is needed for a true explanation of these otherwise strikingly good fitting correlations. Indeed, space syntax's predictions for pedestrian movement and navigation are its most successful area (Bafna 2003) and have therefore also seen applications in historical settings (e.g. Craane 2009; Stöger 2011; Griffiths 2012a). Also when studies comment on social cohesion and segregation, space syntactic argumentation is almost exclusively tied to movement and rudimentary accessibility (e.g. Conroy Dalton 2007; Hillier & Vaughan 2007). Movement — specifically natural movement as an intrinsic psychologically conducive property of configurations — has been theorised and the correspondent measures adjusted, confirming that it seems that distance is governed by topology in way-finding (Hillier et al. 1993; Hillier & Iida 2005).

The evident problems in space syntax are to do with the fact that in everyday life movement is often not only about functional and effective way-finding and that all actors are considered to be similarly informed, disregarding a sense of familiarity. This limitation might still be informative for planning additions to configurations, but less so for understanding the intricacies of life in extant cities. The way spaces which are actually occupied and connected are characterised on a socio-spatial and experiential level, is not a structural part of space syntactic measures. It seems a rhetorical question as to whether it is socio-spatially more significant to understand the interactive opportunities associated with the material situatedness of a space or to 'read' its measure of connectedness to a whole system of spaces of unknown quality (if that awareness is truly possible). The analytical measures generate quantitative and visual values for the abstract space syntactic pattern with probabilistic and predictive aims, which is not commensurable with how the methodology in this study aims to support exploration and interpretive understanding of built spaces themselves. Or, in other words, we do not (yet) know how space syntactic measures are socio-spatially significant for the constitutive process of inhabitation.

Applicability of space syntax

As Steadman (2004: 484) puts it, one of the most significant findings of space syntax studies is “that the pattern of movement in a city or urban area is likely to be shaped to an extent by the topology of its route network alone, irrespective of all other factors.” The focus on movement and accessibility, often in association with lines of sight, implies space syntax’s emphasis on streets and grids (e.g. Hillier 2007; Omer & Zafrir-Reuven 2010). This actually limits space syntax’s immediate application to ‘strange towns’, which includes the highly irregular geometry of low-density patterns of Maya urbanism (see Hillier 2007). Hillier explains his symbolic characterisation of their built form as opposed to the instrumentality of ‘normal town’, which flagrantly overlooks that these cities must be functional everyday living spaces[83] just the same (also Hohman-Vogrin 2005, 2006). While Maya cities are known to have few formal streets (Magnoni et al. 2012), there is much differently organised open space, which can be designated as BLTs (**Chapter 7**). At the same time, critical application of space syntax (cf. Griffiths 2011) is slowly being tried by Mesoamerican archaeologists (Morton et al. 2012a, 2012b). More appropriate social and more historically critical analyses might become possible by careful reconsiderations of space syntax’s foundation and progressive adaptations of its spatial concepts and analytical measures (*sensu* Griffiths & Quick 2005; Griffiths 2011).

The constitutive social theoretical framework of this study does not deny that spatial configuration is an affording factor of the interconnectivity and permeability that allows and guides movement and land-use patterns. However, the analysis of spatial configuration here does not contend to elicit direct causal relations about what actually will occur in space (including movement). Although space syntax, as opposed to comprehensive Conzenian urban morphology, essentially does not concern land-use,

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[83] It is noted that anthropological and archaeological spatial layout analysis often relies on highly symbolic and cultural interpretations (e.g. Douglas 1972; Schwerdtfeger 1972; Ashmore & Sabloff 2002; Atkin & Rykwert 2005). These approaches have not disappeared, but now exist alongside a growing presence of more formal, especially space syntactic studies (Cutting 2003; Thaler 2005; Van Nes 2011; Morton et al. 2012a, 2012b, forthcoming; Fisher 2009; Stöger 2011; Paliou & Knight 2010).

land-use is presented in terms of successfulness determined by spatial movement values (i.e. what will occur). Space syntactic support for the likelihood of this comes from correlative hypothesis testing (see Hillier & Penn 2004), which is quite distinct from the knowledge production process proposed here (see **Chapter 2**).

By applying BLTs, the potential for movement or any other use becomes qualitatively characterised and its socio-spatial position within the configuration contextualised in formal socio-spatial descriptions of each space. This may narrow down likely functions within materialised spatial settings (cf. Sayer's (2000) spatial independence), but does not express the probability of something occurring within a specific space. Moreover, within this study's temporal view, logically the relationship between action (including movement) and layout is recursively constitutive (or continuously dialectical). That means preferential causal weight can neither be allocated to the configuration nor to land-use patterns as attractive fixed locations in which specific actions dominate (cf. Hillier et al. 1993). It can be agreed that through its common application to road networks and pedestrian flows, space syntax offers persuasive correlations, and it is its ability to generate such correlations that can lead us to significant questions. In general space syntax offers a family of ideas and tools with which it is good to think, and that includes deeper historical situations (Griffiths 2012b). In this sense, studying patterns in the socio-spatial ontology intrinsic to the city (see **Chapter 5**) as composed of boundaries could complement the discussion of activity centre spatial signatures in Vaughan et al.'s (2010) perspicacious space syntax application.

Although its theoretical foundations and operationalised concepts have been highlighted as problematic, to its infinite credit, space syntax as a method has enabled researchers to meticulously investigate the topology of the spatial configuration shaping the built environment specifically. Its approach is of particular interest here, because of its claims to study the influence of configuration on social life. Space syntax could be argued to have opened the eyes of social scientific research to the relevance of spatial configurations. In the study of urban built environments, the fundamental conceptualisation of spatial configuration is key for space syntactic innovations (Bafna 2003; Pinho & Oliveira 2009a). In Hillier's (2005: 3) own words: "Cities are large physical objects animated and driven by human behaviour. By far the most interesting and difficult questions about them are about how the two connect: exactly how is the physical city linked to the human city?"

While the theoretical deficiencies have required building up a methodology anew, its fundamental interest in society-space relations and how it connects this to thinking about topology with the aid of computation offers compelling directions for developing analytical measures on the basis of BLTs (**Chapter 8** on understanding analytical measures). In this sense the similarities go far beyond sharing a similar input dataset (base plan). As has been made explicit throughout **Chapters 3** and **4**, boundaries make up the composite complex of the urban built environment configuration. As socio-spatially defined BLTs they form a contiguously connected topology that characterises the socio-spatially significant ontology intrinsic to a city (**Chapter 5** on levels of socio-spatial significance). So, boundary concepts come to describe how, from a single boundary merely conveying a spatial relation (*sensu* Hillier et al. 1987), the whole configuration emerges in terms of constitutively significant interaction opportunities. Due to the conceptualisation of BLTs, this includes much more detail and information on the relation between built volume and open space as well as within open space than space syntax, without losing comparability.

Efforts to combine and integrate methods

While the discussions of the preceding methods have been presented as related but disparate (cf. Whitehand 2010a), this final section is dedicated to efforts to draw together the links between the methods. Furthermore, this will be associated with some aspects of the nature of a GIS based boundary method. Following Ley's (2012: 78) characterisation, virtually all of the work cited and drawn on in this chapter is conducted by urban morphologists: those engaged in working on urban form, featuring "tangible form and intangible processes, present fact and reconstructions of the past, shared usage and individual creation." This unites practitioners from many disciplines (cited here are primarily geographers, historians, architects, planners, and archaeologists) and their methods are appropriate for different aims.

Following Lynch (1981), Kropf (2009) argues that the branches of the theory of urban form should interconnect and support each other; morphological approaches to studying city space should especially represent a confluence of the findings of other disciplines (although due to known discrepancies in approaching built form comprehensive unification might remain beyond reach). "There is the disparity between the fact that cities are the result of deliberate and coordinated human effort [design] on the one hand and exhibit characteristics of 'self-organization' and emergent behaviour on the other." (Kropf 2009: 106) The approaches here have in common that they work from an existing complex which lacks a clear definition for both itself and its composing objects (elements) (cf. Kropf 2009). In this research, however, the source material (i.e. urban built environments) is preceded by an *a priori* understanding of it (**Chapters 1-3**), by which any enquiry is led.

Recapturing the preceding discussion, historically (and archaeologically) reconstructed plans follow a methodological procedure based on certain urban morphological principles, but on the whole work towards a different objective than interpreting socio-spatial significance of material presence as defined for this study. Urban historical GIS may be related to urban morphology on social historical grounds and use a flexible computational platform for its work, but ultimately neglect the empirical social reality of the spaces inhabited by society (see Tilly 1996; Griffiths 2013). As a specialist GIS adaptation, the OH_FET model caters to archaeologists and historians by documenting the physical properties of which urban space is made up, but by privileging change and temporality ends up serving conservationists with spatial limitations and social particularism. Urban morphology may be based on built form and enables the construction of ontological hierarchies, but eventually it mainly qualifies urban space through explanatory planning and building history. Finally space syntax analyses built form, especially topologies, to correlate with social observations and test socially relevant hypotheses, but its methods unwarrantably reduce the empirical lived materiality of its subject matter, and it falls short on social theoretical, material, and constitutive grounds. "It is necessary to set out clearly the scientific aim of the endeavour and make clear that the categories and criteria involved are inherent in the study rather than the study object."[84] (Ley 2012: 79) Whether one's idea of the city is formed by a design oriented purpose, as a deliberately planned or an emergent entity, the approach to its study may differ according to specified research objectives.

It should be stressed that none of these methods claim to serve the interpretive understanding this research set out to enable, a logical consequence of its theoretical framework and concepts postdating the existence of these methods, so what are presented as apparent shortcomings may still serve different and complementary aims. Larkham (2006) suggests (British) urban morphology has yet to structurally exploit the possibilities offered by GIS (but see Pinho & Oliveira 2009b; Koster 2009) as well as the complementarity between urban morphology and space syntax specifically (also

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[84] On this basis space syntax could be argued to theoretically confuse its proposed social aim with studying its own spatial abstractions.

Sima & Zhang 2009). Recently he has been joined in his plea for complementarity and integration on various occasions (e.g. Kropf 2009; Pinho & Oliveira 2009a; Sima & Zhang 2009; Whitehand 2010a, 2010b). However, for true integration, degrees of compatibility in the way 'urban form' (or specifically the urban built environment) is treated should be determined. The uptake of such pleas in terms of real attempts to combine is scarce (a notable exception is Griffiths et al. 2010), which is testimony to the great conceptual work that still needs doing (Kropf 2009; Whitehand 2012) and in the case of space syntax a degree of methodological solipsism seems at play too (cf. Ratti 2004b).

Jones et al. (2009) demonstrate the potential, arduousness, and inflexible limitations of integrating space syntactic results in GIS based mappings. The visualisations that are so particular to space syntax and make its results readily intelligible to the untrained eye are difficult to replicate with the same clarity and interpretive adjustability in a GIS environment. The software plug-in Confeego (Gil et al. 2007) brings many space syntax tools to MapInfo Professional and enables the import of Depthmap results. Since the space syntactic software package Depthmap became open source, opportunities towards effectuating computational integration have been opened from that side, although in reality urban morphological practice has only infrequently been adapted computationally. Some initial steps were reported on by Koster (1998). These steps resemble customary archaeological GIS mapping, early reconstructive mapping, and include comments on the utility of map overlays (cf. *Tokyo Cityscape* (Amherst College, 2009); *Paris Cityscape* (Amherst College, 2010)). As discussed above, GIS software has been aiding historically reconstructive mapping practice (Lilley et al. 2005, 2007; Lilley 2011a, 2012, n.d.; Dean 2012a; Bisschops 2012), while its visualisation abilities have shown to be of comparative morphological merit (Lilley et al. 2005, 2007). The potential of GIS for developing comparative urban morphological studies is also argued by Koster (2009).

What speaks from these contrasts and attempts overall is the fact that computationally the obstacles are mainly in overcoming the labour effort required to enable the technical possibilities. Although space syntax abstractions are not necessarily commensurable with the realistic mapped representations in GIS, there is no reason why they could not be shown and correlated in geographically represented space and any associated data markups and concepts (cf. Koster 2009; **Chapter 5**). At the same time there is no established GIS practice (cf. Pinho & Oliveira 2009b) for mapping according to urban morphological principles and concepts, while comparatively appropriate concepts are still lacking (Kropf 2009; Whitehand 2012). Throughout the above discussion of extant methods, similarities and differences with applying boundary thought have been pointed out. Within the ongoing effort in developing comparative concepts, I believe the BLTs will add an important interpretive possibility, while maintaining options for future integration with the methods described.

Chapter 7 will now develop a commensurate mapping practice based on datasets of disparate origin. In the current context it is relevant to point out the following. As boundary lines in principle trace the outlines of realistic mapped representations of empirical features, the base plan of a boundary approach maintains the possibility of carrying out space syntactic reduction and urban morphological ontological subdivisions, while retaining sufficient detail for locating urban historical GIS documentation references to people and events, as well as the generic quantitative analysis of dimensional or metric variables represented by any GIS mapped data entry. In addition the database structure of a GIS makes it possible to invest all mapped BLTs and analytical derivations with additional values and attribute information (e.g. architectural, economic or affective). On the basis of the data structure emerging from the mapping practice, **Chapter 8** will subsequently discuss and provide a rationale for a spectrum of analytical possibilities, from which a sample is examined in **Chapter 9**.

CHAPTER 7 – MAPPING BLTs, TWO CONTRASTING CASES OF APPLYING CONCEPTS TO EMPIRICAL DATA

Introduction

At this stage all conceptual preparations and a methodological context have been put in place to advance a method that is both conceptually appropriate and commensurate with the specified information contained in the inhabited urban built environment which this research studies. This chapter therefore serves to introduce the processes of data acquisition, preparation, and BLT identification, which is executed as a mapping practice in a GIS environment. This leads to a data structure that can be visualised, questioned and analysed as will be shown in **Chapter 8**. To make the operationalisation of boundary conceptualisations intelligible, the process will be demonstrated via two selective test cases for which a rationale will be provided also.

Towards a method

It should be stressed that the original acquisition of material-spatial (urban layout) data is not part of the research process reported on. Although it could rightfully be argued that knowing exactly what is needed to apply a boundary approach could inform an effective and original data acquisition process, it is emphasised here to the contrary that the fact that existing or ‘legacy’ datasets can be used is a particular strength of the presented workflow. Considering that the basis of the research is always a survey leading to a large-scale urban plan, it would immediately be compatible with a large number of existing town plans in all regions and time periods. This is significant with regards to building up a body of data leading to synthesising comparative studies across examples. Moreover, in most cases, a new comprehensive urban survey on site would be unfeasible, which severely limits the potential merits of the method. This applies especially for the often arduous tasks of archaeological surface surveys and excavation, but also for the laborious process of historically reconstructing a town plan, while equally for present-day cities comprehensively walking and mapping the material specificities of the built environment would be no mean feat. Only by accepting the limitations this would put on material information, could remotely sensed layout plans be generated more quickly than the alternatives. A research practice capable of working on legacy data, then, creates the greatest immediate versatility and allows the researcher to revisit urban landscapes that were studied previously, contrasting current insights with the outcomes from this new method. Nonetheless, as will be shown below, using any pre-existing map, inevitably produced for different purposes and conventions (see Wood 1992; Monmonier 1996; MacEachren 2004; Lilley 2011a; Lilley 2012, Hutson 2012, Beisaw & Gibb 2013), will present its own challenges and limitations. An important technical challenge that becomes integral to the research process is the need for digitisation (exemplified in this chapter) of many legacy maps which only exist as physical documents.

Using extant or legacy city plans, this research method is inevitably dependent on the mapping practices in other disciplines. In archaeological cases the professional expertise of the surveyors and/or excavators is relied on. In historical cases the professional expertise of historians and historical geographers is relied on. In contemporary cases the professional expertise of the relevant mapping agency and/or (academic) surveyor is relied on. As discussed in **Chapter 6**, the research leading to historically reconstructed city plans has exclusively been developed in (medieval) European contexts so far, roughly limiting the extent of the time-depth for which time-slices would be available at approximately regular intervals. In order to demonstrate the comparative abilities of the methodology, as already incorporated in the way the theoretical framework and conceptualisations have been formulated, the two test cases have been deliberately selected to represent two very different situations. The rationale for selecting these test cases thus forms the starting point for this chapter. It should be noted that, while limited test cases are used here to demonstrate the methodology developed, the cities providing the test cases were originally selected with the potential for a broader and more profound full-fledged case study in mind.[85]

[85] Because the overarching emphasis within this research project is on the development of a methodology, the examples throughout the following chapters are demonstrations of processes and possibilities, but do not aim for a comprehensive commentary on or interpretation of the test cases.

Selecting case studies

Western urban tradition

The first consideration for selecting two appropriate test cases consists of ensuring that they represent two considerably dissimilar urban traditions in order to highlight comparative potential. The familiarity of the urban context which I have myself most directly experienced (Leiden, The Netherlands and Leeds, UK), which is part of what can be generalised as the urban tradition of the western world (e.g. contributions in Slater 1990), would be a convenient place to start. It cannot be denied that there will be a greater *a priori* understanding available of the kind of context one is oneself related to. The widespread examples of cities of medieval or earlier origin in both the UK and The Netherlands increase the chance of finding a test case for which historical depth can be maximised. In this way not only the cross-cultural but also the diachronic comparative ability can be demonstrated.

So decided, the search was limited to cities in The Netherlands or the UK for which appropriate data are available and/or could be compiled. Next to a western contemporary example with historical depth, the method should be developed for archaeological cases, thereby maximising its applicability across the whole of the human phenomenon of urbanisation. While in Classical and Near Eastern archaeology numerous urban settlements have been mapped to a sufficient extent, these urban traditions are characterised by both a density and degree of regularity within the built environment that *a priori* is readily related to contemporary western cities. Although this should not be confused with concluding that these cities were inhabited in a socially similar way (cf. Fletcher 2010; **Chapter 1**), to truly test the comparable applicability of the boundary concepts it would be more advantageous to select an example of the nowadays alien irregularity of low-density urban tradition (see Fletcher 2009, 2010, 2012). Further supported by the earlier debate on the urban character of Maya cities, as well as a wider availability of archaeological plans for Maya cities, and the added convenience of personal contacts in that specific research area, the Maya urban tradition makes a suitable area for sourcing a second test case.

Although this is not the place to provide a historical overview of cartography, in selecting a Dutch or British case study it is important to realise that the production of city plans was exceedingly rare till the later 16th century. The most notable publication may be the *Civitates Orbis Terrarum*, which consists of six volumes published between

1572 and 1617. This work brought together 546 images or prospects on cities all across world at the time. Not all of these are city plans — there are various orthographic views as well — and those which could be recognised as a city plan would in no way reflect the mapping standards we know today. The *Civitates Orbis Terrarum* was edited by Georg Braun and primarily engraved by Franz Hogenberg, though it combined the work of many different artists and cartographers[86]. Jacob van Deventer (1505-1575) and Joris Hoefnagel (1542-1600) are two pioneering cartographers that produced numerous of the city plans contained in the volumes. Jacob van Deventer maintained a meticulous working method, which when complete would contain two maps per city. A ‘minuutkaart’ formed the overview of the entire city plan, based on measurements and sketches combined into a whole, while the ‘netkaart’ consists of a mapping of the city’s surroundings, sometimes accompanied by a ‘bijkaart’ depicting the city’s major features in the centre, including defences, streets, and significant buildings. 221 of Van Deventer’s city plans of the Low Countries are still preserved in one, two or three publications (for more detail on Van Deventer, see Vannieuwenhuyze & Lisson 2012). A comprehensive town mapping effort in the UK, after those included in the *Civitates Orbis Terrarum,* was carried out by John Speed (1552-1629), published between 1610 and 1611. Little mapping of cities generally took place between Speed’s efforts and the Ordnance Survey maps of the 19th century (Carter 1972).

When no historical or archaeological studies have uncovered much about the city’s history and little of the historic city is preserved in the current urban tissue, archived historical plans may be the most direct sources on the historical situation of the built environment. However, Lilley (2011a) stresses that historical maps typically are the result of artistic interpretation of the built environment and furthermore these maps do not follow the contemporary knowledge of projection systems. It is not till the 19th century that mapmaking reaches the conventional and scientific standards upon which current standards are built, which is why urban morphological studies (see **Chapter 6**) usually depart from the earliest appropriate 19th century city plan. Because of their nature, Lilley says, historical maps are almost impossible to geo-rectify. Even if this is done successfully, the results might be futile as mapped features might not correspond to what was actually there. This is why the critical historical and geographical research practice of reconstructing town plans is pertinent for the detailed study of the urban built environment beyond the 19th century.

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[86] The information on the *Civitates Orbis Terrarum* is derived from *Historic Cities* (undated).

The Historic Towns Atlas[87] project, with editions extant in both the UK and The Netherlands, is a logical initial port of call for finding out about relatively well-studied examples of historical cities (Lobel 1969; Speet 1982, 1983; Doornink-Hoogenraad 1983; Visser et al. 1990).[88] Nonetheless, because these atlases do not reproduce the historical situation for the built environment beyond the 19th century, their usefulness for research purposes has been questioned (e.g. Slater 1996; Rutte 2008). For the purposes of this research it was found that although there is potential for historically reconstructed maps to be produced for examples in The Netherlands, such is actually not currently available. Notably, the city of ‘s-Hertogenbosch boasts an appropriate basis for such effort (Rutte *pers. comm.* 2011; Van Drunen *pers. comm.* 2011), as relatively speaking much archaeological work has been carried out over the years,[89] and Van Drunen holds a GIS with the architectural historical surveys of some 3000 buildings, with 1700 buildings within the old expanded city walls. However, undertaking such integrating and reconstructive work could make the subject of a research project in its own right and it was therefore not feasible to serve as a test case location.

Within the UK the medieval New Towns of Wales have been the subject of historically reconstructive mapping (Lilley et al. 2005, 2007), but Lilley (*pers. comm.* 2011) advised that otherwise knowledge is limited and the cities would probably have remained too small over time to have seen major change and development into the present. Although this research will be limited to a test case area, the potential to later upscale the selected case to incorporate the whole city as an illustrative research project was deemed important upon selection. It transpired that only Chester (Vetch et al. 2011; Lilley 2011a) and Winchester (Keene 1985) had further comprehensively been the subject of historically reconstructive or sequence mapping. The more recent work on Chester only produced a time-slice for the situation of around 1500. Although the integrative effort, including archaeological knowledge and the use of current GIS mapping techniques, would have created a better immediate basis for the work necessary here, Keene’s work on Winchester included three time-slices (1550s, 1417, 1300s) and set the benchmark for historical work on city environments for long after its

[87] A list of atlases produced by the European project can be found on the website of the *Irish Historic Towns Atlas* (undated). The *British Historic Towns Atlas* (undated) has also been revived in recent years.

[88] The other Dutch atlases of Amersfoort, Venlo, and Bergen op Zoom were not readily available for consultation, but follow a similar set-up to the ones cited here.

[89] An overview of such work and projects can be found online at *Bossche Encyclopedie* (undated).

appearance (Bisschops *pers. comm.* 2011). Winchester, like Chester, is a typical historical English (and western European) example of a densely settled urban landscape based on a persistent medieval pattern with Iron Age and Roman antecedents (cf. Conzen 1960). Winchester was selected to provide the test case area for this research, due to its potential for greater time-depth[90] and the opportunity to exemplify the opportunities offered by digitising legacy data. Its mappings completely result from a historical research process (see Keene 1985), which could be significantly improved upon with inclusion of dispersed archaeological records (e.g. Scobie et al. 1991). Nevertheless, it also offers the opportunity to demonstrate the differences between purely archaeological survey and historical research efforts, which are the two disciplines that can provide the source material for a social scientific study of the inhabited urban built environment.

Finally, it should be remarked here that none of these reconstructive mapping efforts goes down to the level of individual buildings, as urban morphologically and historically the records typically refer to the building plot rather than what occupied it. This means that for the purposes of the boundary approach, additional working conjectures are necessary to rectify this absence. This will be part of the method described later in this chapter.

Maya urban tradition

The Maya case study was selected primarily on the basis of intensive mapping efforts and thus the availability of data. Although recent years have seen technological progress advance the availability of increasingly detailed and comprehensive archaeological city plans (see Evans et al. 2007; Marcus & Sabloff 2008; Sinclair et al. 2010; Chase et al. 2011a, 2011b), in terms of currently available plans of Maya cities, traditional surface surveys of visible remains and topography are relied on. This also implies that a fully comprehensive plan on the level of detail required may not exist, even though some archaeological sites have been mapped to a very large extent.[91] Due

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[90] Keene's (1985) work was preceded by Biddle's (1976) volume on early medieval Winchester. The plans contained in this volume, due to the restrictions of fragmentary historical and archaeological evidence, could not be prepared on the same plot level of detail as Keene's plans and thus would not be suitable for this research method.

[91] No comprehensive overview of the research on and mapping of Maya urban sites exists. This tentative conclusion was reached after a search of well-known Maya sites, basic literature and consulting several Mayanists for their opinion.

to increased visibility of archaeological remains in the Maya lowlands of the dry north of the Yucatán peninsula, better mapping has traditionally been possible there. This revealed two likely candidates to provide a test case. The first is Mayapan, originally mapped in 1950s (see Pollock et al. 1962). After several other projects, Russell (2008) recently added extramural areas and estimates, and currently the mapping is further improved on and fully integrated by the *Economic Foundations of Mayapan Project* (PEMY) (undated), directed by Marilyn Masson (see Hare & Masson 2012). This last project also plans to include a LiDAR survey (cf. Chase et al. 2011a, 2011b) of the area. Mayapan is a relatively unusual site as it was one of the latest major centres of the Maya culture area. Furthermore, it is known for featuring a high density of architectural structures in comparison with other Maya sites and is also characterised by having been walled. Few defensive walls are known in the Maya culture area, especially after recent doubt was cast on the existence of such defence works in Tikal (Webster et al. 2007; Silverstein et al. 2009).

Due to the quality of mapping and the early availability of a comprehensive plan for the walled city, some spatial analysis has been tried on Mayapan. Pugh (2003) studied specified building type configurations and associated cluster analysis on ritual or ceremonial architectural assemblages. Brown & Witschey (2003) conducted fractal analysis on Mayapan to support an argument of interpreting the existence of administrative self-organising subunits. Hare & Masson (2012) extended such studies, especially based on a variety of basic metric density analyses, acknowledging that there may be several political or societal models at play. By looking at the density of 'elite building types' (cf. Folan et al. 2009), in relation to other features and specifically wanting to connect polity administrators to local populations, they made an attempt at understanding the neighbourhood structure of Mayapan (see also Adánez Pavón et al. (2009) for a spatial modeling of political catchment areas on the basis of plaza groups). The existence of a thoroughly evolved and digitised city plan and previous spatial analyses would have made Mayapan an effective foundation for a test case here. However, as the PEMY project is still ongoing, data provision proved an issue.

The other site featuring a detailed and extensive city plan is Chunchucmil, located in the northwest of the Yucatán peninsula. Although the full city plan of Chunchucmil has not been published yet (Hutson et al. in prep., is expected to include this), Scott Hutson kindly agreed for me to use their material (courtesy of the Pakbeh Regional Economy Program). Due to its Classic Period (generally ca. 200-900 A.D.) apogee of occupational remains, here 5-6th century A.D. (see Hutson et al. 2008), this site is more easily related to the prominent Maya urban centres (e.g. Tikal, Calakmul, Palenque, Caracol, etc.) of what is traditionally regarded to be the pinnacle of the Maya culture area (see e.g. Sharer & Traxler 2005; Andrews 1975). Nonetheless, it should be noted that Chunchucmil also features a relatively high density of architectural structures over a relatively large core. This leads it to be defined the most densely occupied Classic Maya site (Magnoni et al. 2012) by current population research principles (cf. Rice & Culbert 1990; Sharer & Traxler 2005), despite its unfavourable natural environment. At the same time this could also reflect the good visibility of archaeological remains across the site (Hutson *pers. comm.* 2011-2013) and the scarcity of synthesised results from comparably intensive and comprehensive mapping surveys. Furthermore, its density of architectural structures is not completely unparallelled even for the Classic Period (cf. Barnhart 2005) and is still considerably lower than Postclassic Mayapan's intramural core.

In addition, Chunchucmil is unique in the extensive occurrence and persistence of structural patterns of *albarradas* (Magnoni et al. 2012). Albarradas are often defined as dry stone houselot walls, which are more usual in the Postclassic (Hutson et al. 2007; Hutson et al. 2008), but their use appears to be much more diverse in Chunchucmil and across the few Classic period sites where they have been found (see Magnoni et al. 2012). Nevertheless, it has been suggested that the divisive principle of albarradas might have been much more widespread, but simply not preserved because perishable materials might have been used for their construction instead of stones (Becker 2001). A consequence of their preservation (stone and rubble construction) at Chunchucmil means visually the site offers what seems to be a much more complete picture of the social reality of the built environment. At the same time, one should remain aware of the probable ample use of perished materials in complementing the preserved built environment with e.g. internal activity arrangements (cf. e.g. Becker 2001; Manzanilla & Barba 1990; Hutson et al. 2007; Hutson et al. 2008; Magnoni et al. 2012). Magnoni et al. (2012) recently also conducted some preliminary spatial analysis on the house group assemblages and houselot areas, within a GIS with limited functionalities (Hutson *pers. comm.* 2013). Especially considering the expectation that recent developments in mapping technologies will yet reveal more equally mapped examples of (Classic) Maya urban centres, the superior visibility, detail, and large extent of the mapping at Chunchucmil makes this a very appropriate basis for a test case of the boundary mapping method.

A final word of caution should be uttered with regards to the assumption of contemporaneity within Maya city plans. As these are not cities with still ongoing inhabitation (they usually were abandoned either before or after the Spanish conquest) the archaeological remains on the surface are likely to date to various periods. Now, this is in keeping with the urban landscape as an inevitable palimpsest (see **Chapter 6**), but archaeologically the argument of approximately simultaneous occupation across an entire built environment complex is less straightforward to make than when using historical records. For Chunchucmil the artifact assemblages roughly indicate a consistency for Classic period occupation across the whole site including the finger settlement extensions (Hutson et al. 2008; Hutson *pers. comm.* 2011). Nonetheless, beyond there is a central barricaded portion that indicates Terminal Classic and even later reuse of the monumental core (Dahlin 2000; Hutson et al. 2008). Hutson reassured me that the assumption that the entirety of the site was once approximately simultaneously in use is relatively safe to make. In preparing the data, however, some decisions on poor preservation and mapped truncated structures will need to be made.

Preparing the datasets of Winchester and Chunchucmil (1)

From here on the chapter mainly follows the workflow of creating BLT data and the numbering in the headings refers to this. This workflow can be summarised as follows:

1. Preparation: acquiring, assembling, digitising, and converting the source materials to the same format (usually extant or legacy spatial data and/or maps);
2. Creating equivalent spatial information by mapping (tracing) the outlines of major occupiable subdivisions of the built environment represented in the source material;
3. Case specific conjecturing to resolve any data gaps (data needs to be spatially contiguous) and revising the resultant outline base plan;
4. Remapping the base plan by identifying the BLTs and revising and correcting the integrity of the resultant spatial data.

Preparing in the first place means converting the mapped data to an equal and appropriate digital *format* across all datasets, before further preparation to ensure the digital datasets basically represent the same level of conceptual detail and conventions to convey *information*. In **Chapter 6** the potential of GIS software was already mentioned. ESRI's ArcGIS, version 10, was used as the primary GIS environment to conduct the methodologically specific mapping. ArcGIS was selected because of its widespread use in academic contexts, both in geography and archaeology, as well as its versatility in handling topological information in vector data (i.e. lines, points, and polygons, lines and their connections being of paramount importance here). Nonetheless, in digitisation and data conversion other software packages were used, which will be stated in the accounts that follow.

Winchester maps

The following account of the data acquisition is a concise version of the log of the workflow maintained during the work and omits the less generic technical details that would not help overall understanding. The focus will be on the sequence of work and decisions for data preparation that produced usable results. In addition, it is expected that much of the software based work sequences could be superseded by software updates, meaning that the principles are more important that the precise activities within the software. Where relevant, the processes will be mentioned and described.

The Winchester city plans used consist of both the present-day situation and historical situations. The contemporary situation is based on the current large-scale mapping standard of the British Ordnance Survey, called Master Map (from here on: MM). MM is a digital product of the Ordnance Survey (from here on: OS), updated up to every six months. The version for Winchester used was downloaded end of October 2011 (using the University of Leeds academic license for EDINA services) with the OS providing the complementary *OS Imagery Layer* (OS official aerial photography) and *OS Address Layer* (version 2) on disc in April 2012. The first historical time-slice is based fully on the first edition of the large-scale (1:500) OS city plan published between 1871 and 1872 (from here on: OS1872). This is in keeping with common practice originating from urban morphology (see **Chapter 6**). The additional time-slices are sourced from the reconstructed plans for the later medieval period by Derek Keene (1985), respectively for around 1300, 1417, and 1550. The test case will be limited to the period around 1550 (from here on: 1550s) within the confines of this research, the processes for preparing and using the further two time-slices being equal.

It should be mentioned that between the first historical (but according to modern ideas of accuracy) 19th century plan and the 1550s, the 1750 Godson survey was also considered as the basis for an additional time-slice. After digitisation this historical document compiled from the two four sheet copies in the Bodleian Library’s collection and georeferencing these images in GIS, it soon transpired that not only would the historical survey technology, style of depiction, and imprecise edge matching of the printed sheets, make a topographical challenge, but also the detailing of the plan left many building and plot details ambiguous. This impedes any direct spatial interpretation into representative individual topographic features without requiring much additional original historical research to that period and the survey techniques, which is outside the methodological scope of this research. Future research could still consider taking the 1750 Godson survey on. Equally, throughout the 20th century more detailed city plans have been published which could serve as additional time-slices, providing further temporal specification.

It should be noted that the three city plans used are thus of a different nature. MM is a born digital plan, delivered with instruction to convert into a fully functional GIS format, according to the best British national mapping standards of accuracy. OS1872 is, although produced to be accurate, essentially a historical document. It is acquired through the academic license of the University of Leeds on EDINA's Historic Digimap service, providing geoTIFFs (i.e. TIFF image files with a basic level of georeferencing: projecting, locating, and scaling it) of the scanned original sheets. Finally, 1550s is a historically reconstructed map, dependent on the academic cartographic and historical research practice producing it.[92] Interestingly, the mapping practice of OS1872 is more detailed that the current MM. However, the burgage plot based historical research of Keene (1985) means the level of detail (e.g. omitting any architectural morphology) is very basic indeed and, as mentioned, does not include building outlines. Nevertheless, before any work can be done the digitised OS1872 needs to be vectorised and related to MM, while 1550s needs digitisation and vectorisation to be geospatially related to other two.

The Keene plans of medieval Winchester needed to be digitised. They appear at a 1:2500 scale in Keene (1985), separated out in numerous small sections. These could be scanned from the books and digitally stitched together, but the match errors of so many stitch seams would compromise the quality of the resulting plan as a whole. Therefore the originals were traced down to the Winchester Research Unit (curated by Martin Biddle and Katherine Barclay), which stores them in the depot of the Winchester City Museum. These originals consist of large sheets of film on which the line drawing of the map was draughted. These sheets represented the medieval city in five parts: the

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[92] It should be noted that Keene prepared his plans in reference to the then current OS city plans of the 1970s, which used planimetric technology closer to present standards (Keene *pers. comm.* 2012). In addition the 1872 OS plan and the 1750 Godson survey were used as points of reference for shaping features in the built environment (Keene 1985).

walled area, and the north, east, south and west suburbs. The large-scale of these original sheets as well as the less fragmented and unannotated nature of them would likely increase the quality and direct usability of the digital end product tremendously.[93] To avoid photographic lens distortions in the digital reproductions, digitisation took place using roller scanners. These scanning machines are able to scan large physical documents like a flatbed scanner. The huge resulting raster images at high quality 400-600 dpi resolution needed to be cleaned up and filtered to remove digital noise and original blemishes on the films, enhanced for contrast and definition, and stitched to create a whole out of the five sheets.[94] To keep the files manageable a resolution of 400 dpi was deemed sufficiently sharp for the definition of the line drawing at full scale.

Assuming the current national mapping standard of the UK as technologically the most accurate representation of mapped features, georeferencing and georectification of the historical time-slices is carried out in direct relation to MM. This is preferred over setting up a proper set of control points on site with dGPS (differential GPS, cf. Lilley 2011a). The error margins involved with taking original GPS measurements could cause unwanted discrepancies between the points taken and the MasterMap data, causing an unnecessary need to rectify MM as well as the historical layers. Instead, with the aid of Keene himself (*pers. comm.* 2011), historically persistent points in the current built environment were identified and photographed on site for future reference. The photo locations and directions were then documented as a GIS layer on top of MM as point data, as the photographs themselves show little context. Following expectations of the development of the built environment over time, there are fewer historically persistent points that originated from the 1300s then each more recent time-slice. These historically persistent features served as an initial set of control points for

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[93] The film sheets were all in relatively good condition, but there is no accounting for any errors resulting from 40 years of ageing of the physical material (Biddle *pers. comm.* 2011).

[94] Proprietary functions in Adobe Photoshop were used for these processes, but Photoshop puts a cap on the maximum pixel count (30.000) in either of the two dimensions of raster files. This may inhibit the use of very large files, requiring one to reduce resolution before processing. The original scans were produced courtesy of Geoff Denford, Winchester City Council, at 400 and 600 dpi. Additional scans of oversized documents were made at the University of Portsmouth by Katherine Barclay at 500 dpi on a larger roller scanner. The quality of definition on the 500 dpi scans was intrinsically superior, possibly due to other technology in the machine, but the lower resolution determined the quality of the final stitched scans. All were visually improved by image processing in Photoshop, thus ensuring readable solid lines, suitable for semi-automated vectorisation (see below). The precision of the plans is inevitably somewhat compromised by the stitching process, which relies on an intuitive visual weighting of matching errors between the seams of each sheet using proprietary graphical processing tools in Photoshop. ArcGIS offers an alternative to match edges of vector files, which is possible if the separate scans were vectorised first.

georeferencing and georectifying the historical layers. Although OS1872 is delivered with a basic level of georeferencing, to achieve a closer geolocation match with MM these control points were used on that time-slice also.

In addition to control points, the geographical representation of listed buildings and monument sites was obtained from the Winchester City Council (courtesy of Ian Scrivener-Lindley and Tracy Matthews). These polygon and point records were prepared on the basis of MM and so would relate exactly to the source data. Unfortunately, heritage listings serve a policy purpose of protecting and managing the sites. This means their shapes cannot be trusted to convey any historical reality. Furthermore, in Winchester the heritage records, often of a dubious and dated standard, have not been fully integrated across the various systems that have existed over the years, and do not include archaeological excavation plans. Only limited and very cautious use could be made of these records, using online resources such as *Heritage Gateway* (undated) and *National Heritage List for England* (undated). In practice, where possible, Keene's (1985) words on the plots concerned were preferred over the details of the listings, but the records were used to indicate plausible historically persistent features for the 1300s through to the 19th century.

After the initial georeferencing process it was possible to select a series of additional points across the city that were clearly related to specific corner and intersection locations in the MM data. The use of these additional points improved the relative accuracy of the whole, using ArcGIS proprietary higher order georectification warps in an iterative and visual process of selecting appropriate points and warps. The result can be found in **Table 7.1**. It should be borne in mind that errors are unavoidable in georeferencing, but here in addition the multiple sheets of OS1872 do not always match entirely, which is an effect of their separate publication over two years on a quickly developing city (see **Fig. 7.1**). The rectification can be fixed by transforming the raster file[95] (most effective is saving to TIF with LZW compression), which creates a new raster dataset incorporating the warp. On this basis vectorisation takes place. Since for OS1872 this immediately entails extracting the base plan, this is described later.

[95] For unclear reasons, the more temporary command 'Update Georeferencing' did not function on the OS1872 files, requiring a transformation directly. A backup of the original raster image in combination with saved link tables makes sure the process can be repeated and corrected if necessary.

Plan	Nr. of Points Used	Warp	RMS error
OS1872	74	Adjust	0.03241

Table 7.1: Results of georectification per historical time-slice
The low RMS error is not a reflection of visual precision, but could be explained by the combination of local and global correctives 'Adjust' uses, which corresponds with the much higher density of control points within the walled city as opposed to the suburbs.

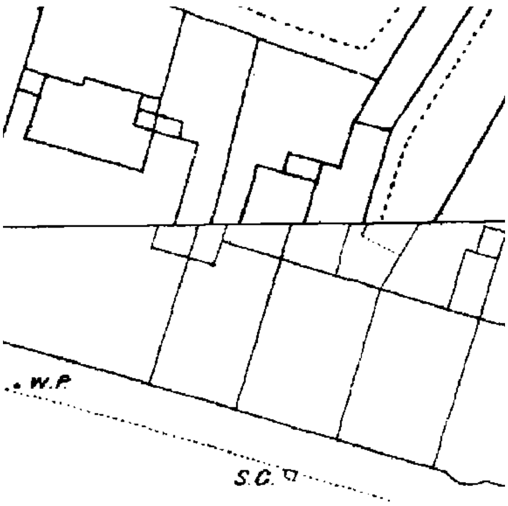

Fig. 7.1: Mismatch at a plan seam in OS1872
The intrinsic mismatches at the seam between two sheets in OS1872 cause inevitable errors in georeferencing. (Image extracted from originals: © Crown Copyright and Landmark Information Group Limited 2013. All rights reserved. 1872.)

Taking into consideration that the eventual test case could only be very limited within the confines of this methodologically oriented research, a small test area (approx. 175x200m, **Fig. 7.2**) was selected to concentrate efforts on in the succeeding work on Winchester. This area was deliberately selected to include an intramural and extramural part of the city where the city wall was removed, so clear contrasts between persistence and change would show. The eastern part of the city centre, around the former East Gate and bridge, seemed to offer a good variety within a historically well-developed suburb of the city. Nonetheless, it should be noted that such a small section could never incorporate the full breadth of variety within the urban built environment concerned.

Fig. 7.2: The test case location indicated within MM of the historical core of Winchester (Extracted from OS MasterMap. © Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service.)

Moving on to the next historical time-slice, 1550s, the approach chosen differs from OS1872. Having produced, cleaned, enhanced, and stitched the scans, the resultant image file is not yet georeferenced at all. The file concerns an unannotated line drawing (similar to **Fig. 7.1**, without text), which implicates it can be classified in two classes only (i.e. a bi-tonal image), making it susceptible to automated vectorisation. Gregory & Ell (2007) clearly warn that although theoretically the historical researcher's best friend, automated vectorisation is not sufficiently effective in practice to take over vectorisation. The extent of manual editing afterwards would be equal to the manual vectorisation process. Several years of development have passed and even on the very clear line drawn map of 1550s it was soon determined that fully automated vectorisation could not be trusted. Issues would occur with undue intermissions at thinner lines, confusion at thick lines, and unintended disorder at dashed lines, as the software does not recognise such patterns. However, ArcGIS's ArcScan suite of tools currently provides a semi-automated form of vectorisation, significantly speeding up the manual tracing of the original image with polylines. This process still requires human intervention to avoid unnecessary ruggedness in the polyline morphology due to the thickness of originally scanned lines, but the upside of this is that one is directly in control of the data produced, reducing errors occurring in fully automated non-interpretive processes. For future reference, Keene's (1985) own original historical conjectures were vectorised in a separate feature class (geodata file) from the features that he deemed certain at the time. On this basis 1550s was vectorised before georeferencing and georectification, thereby significantly improving the manageability of the files in the ArcMap environment.

Confusingly, the process of georeferencing of raster image files is called 'spatial adjustment' in ArcGIS when it concerns geographically relating vector data to another dataset (here the vectorised 1550s layer to MM). Fortunately, spatial adjustment operates on very similar principles and thus ends up being quite intuitive for those familiar with raster georeferencing. Because snapping exactly onto nodes in vector data is enabled in spatial adjustment, much more accurate placement can be achieved (directly connecting the node within 1550s with the respective node in MM). If the internal arrangement of the vector data contains equal scaling, the remaining error should come out nought between co-located nodes (i.e. in the exact same geographical location across layers). Where one is certain the selected node should be identical between the two vector layers, these can be fixed as a geolocated connection (hammering in a virtual nail linking both layers) called an 'identity point'. This means that in subsequent geoprocessing to warp the dataset this point cannot move from its position, contrary to control points in georeferencing. The warp process is called 'rubbersheeting', which entails the stretching of vector data between the identity points (42 were selected in total over an area of approx. 600x600m incorporating the test case area) on the basis of adding additional control points locally to achieve a more precise match. It should be noted that since the test area is very small, this process was carried out for an enlarged area encompassing the test area. In this way enough identity and control points could be selected for the successful processing of the data. No residual error is produced for this process.

Chunchucmil map

Rather different from the city plans of Winchester, the Chunchucmil map results from a completely original survey by archaeologists. It is an example of an intensive surface survey, where the archaeological remains were mapped by using a compass and pacing from the corners of a 20x20m grid system. This system is based on an extant grid left by henequen cultivation and additional theodolite measurements to set out additional grids, using high precision GPS to connect the different grids to each other (Hutson *pers. comm.* 2012). The archaeological plan was originally acquired directly from Scott Hutson (courtesy of the Pakbeh Regional Economy Program) in digital format. Hutson directed and completed the mapping project on Chunchucmil over the past few years, taking over from Bruce Dahlin. This map is yet to be published (Hutson et al. in prep.). Frequent contact with Hutson was invaluable to preparing the GIS, using and interpreting the plan. Being the product of an archaeological survey, it contains the interpretations and professional judgments of the mappers. At the same time, since it regards archaeological remains, it comprises a representation of an empirical material situation as encountered on site. Nevertheless, the exact condition of the empirical situation cannot be conveyed by the lines composing the map. In order to better understand why the lines are mapped the way they are, i.e. their characteristics as lines rather than the legend of what they convey, contact with Hutson was indispensable.

Chunchucmil cannot serve as a diachronic test case, as the abandonment of Maya urban centres left a final phase of occupation contiguously covering a large area (as indicated above (see Dahlin 2000, Hutson et al. 2008), only the core of Chunchucmil seems to have been occupied in a period after the Classic). No large Maya site has ever been excavated in its entirety and the research on earlier phases of development is typically confined to monumental architecture in the centre and individual buildings (Fash 1998). From this we do know that at least for monumental architecture the Maya building tradition consisted of superposing a new phase onto the preceding one. In addition, Andrews (1975) shows a hypothetical evolution of a ‘quadrangle group’ of buildings, in which the group basically increasingly clots together with elaborate architectural volumes from several related but separate buildings. However, we know precious little about the development of cities on a settlement scale. In the case of Chunchucmil the settlement fingers or corridors leading to outlying satellite centres of settlement seem to have at least been actively occupied in roughly the same period as the rest of the city (Hutson et al. 2008). Additional archaeological research is therefore needed to enable any possibility of reconstructing earlier phases of urban development.

This means that for Chunchucmil we are only concerned with the archaeological plan. The purpose of the test case here is to demonstrate the effectiveness and applicability of the boundary approach to a radically different urban tradition. This, in combination with the low-density nature of settlement in Chunchucmil, implies that a considerably larger test case area was selected. On the advice of Hutson (*pers. comm.* 2012) a test case area was selected on the northwest site of the monumental core, where consistent observations lead to the expectation that preservation is slightly better than for other parts of the site. The test case area covers approximately a square kilometre northwest from the site's mapping centre, overlapping a small section of the monumental core. This represents almost a tenth of the total contiguously mapped area of the city and is hoped to contain much of the built environment diversity within, although admittedly it does not contain a part of the most scarcely settled areas of the city. With an eye to up-scaling the test case to a case study in the future and the fact that the site's plan was sourced in its entirety, the initial preparation of the plan has been done for the whole.

The mapping of Chunchucmil took place over a period of twelve years during which many team members were involved in the work. Contrary to more recent archaeological practice, it was early on decided that the city's plan would be documented in the Adobe Illustrator (.ai extension) format. This is not software with GIS capabilities, but image oriented graphic software, albeit functioning in vector format. This means that although the Chunchucmil plan is born digital visual data, none of that data is geospatially stored. Therefore the data had to be converted to an ArcGIS proprietary format and geospatially located and projected before further work could commence. Unfortunately the .ai format cannot be directly imported in ArcGIS.

A laborious conversion process for rescuing legacy Adobe Illustrator data ensued, which was originally set out by Wunderlich & Hatcher (2009). This process could roughly be followed, but new versions of the software packages involved make the processes slightly different. Most of the process takes place in Adobe Illustrator itself, which serves to prepare the data for conversion to other formats and to avoid conflicts or corruption at that stage. There is no need to reproduce this process in full here, as the software is changeable. In general, however, important steps include the separation of all image layers in Illustrator, especially separating out different kind of digital information (e.g. lines from text). Furthermore, as Illustrator uses proprietary techniques to render curves in an automatically generated and smooth way, to preserve the shape of the drawn features the distribution of the anchor points (vertices) needs to be densified. This way the locations of points giving a polyline its more precise shape can be maintained in other formats. Illustrator can then export the layers to AutoCAD format.

On the advice of Wunderlich & Hatcher (2009), a hereditary AutoCAD exchange format was used (the 2000/LT2000 version for .dxf), which is assumed to store information in a simpler and more stable way than newer versions. It is actually not necessary to use AutoCAD software at any stage, although the data can of course be checked. Although ArcGIS is able to import .dxf files, for unclear reasons the ArcGIS proprietary conversion tools produced grossly compromised results without easy repairs. Through trial and error it was found that MapInfo Professional's 'Universal Translator' tools do produce reliable results. Here the file converts first from .dxf into Mapinfo's proprietary '.tab' and subsequently from .tab the same tool can convert to ArcGIS proprietary '.shp' (i.e. shape file). These shape files finally can be loaded without issue in ArcGIS, although text annotations still remained unsuccessful throughout conversion.

Raster file (coverage)	**RMS error**
Chunchucmil's entire plan	0.01945
Block 0	0.00543
Block 1	0.00952
Block 2	0.00339
Block 3	0.00887
Block 4	0.00030
Block 5	0.00072
Block 6	0.00274
Block 7	0.00574
Block 8	0.00605
Block 9	0.00329

Table 7.2: The residual errors of georeferencing the TIFFs from the Chunchucmil plan data
The errors have been kept low by closely zooming in on the relevant intersections of the grid in each raster image, then entering the calculated (thus accurate) coordinates manually into the link table.

In addition to converting the .ai data to sufficiently reliable .shp format, the Illustrator image of the entire map was converted to PDF and in turn in Adobe Photoshop converted to TIFF. As the original map only featured a partial grid around the site's centre, the same was done for the PDFs containing the 10 gridded blocks with feature labelling in which the site plan was organised by Hutson (thus providing coded references for features and improving navigation across the whole plan), which were provided later in 2012. The raster image of the whole plan can be added as a dataset into ArcMap, which then enables essential visual checks for the integrity of the converted vector data and, given that text annotations did not make it through the conversion, these annotations would be retained in the raster image providing interpretive clarity. After assigning the correct projection to the imported raster data, using the coordinates for the site's centre point,[96] the TIFF containing the entire plan could be georeferenced. Knowing the partial grid across the centre consists of 250x250m blocks, the georeferencing could be scaled (using five points on the grid in quincunx fashion). This can subsequently be extended to include the grids of the 10 label blocks by using the four extreme corners of each grid. The results of this georeferencing process can be found in **Table 7.2**.

Next, the generated shape files containing the vector data of the original plan were imported as layers in the GIS. Using the spatial adjustment tools as described above, referring to the four extreme corners of the partial centre grid (this grid was ensured to be included as part of each vector layer when separating the layers in Illustrator before) each layer could be displaced and scaled exactly (meaning literally without any error) onto the corresponding coordinates. With the vector layers now overlaying the raster images, the quality and integrity of the data conversion could be checked per individual detail as well as for completeness. Only very few minute details seemed to be missing (possibly due to Illustrator proper visualisation techniques). Since these could easily be edited manually into the vector data in ArcGIS in subsequent processes of preparation (below), the data was deemed fit for use.

Creating outline base plans and resolving data gaps (2, 3)

The next stage for both test cases is to prepare an outline base plan (conveying equivalent spatial information), which for the convenience of argumentation here will include the third stage of making complementary conjectures. The principle of using the outlines of the major occupiable subdivisions out of which the built environment is composed was explained in **Chapters 4** and **5**. The extent to which features included in the subdivisions are deemed to be part of internal and functional design and thus how soon features of the built environment will be designated a proper outline depends on the resolution and purposes of the research and the researcher's judgment. Inevitably, prior knowledge of the BLT definitions, which are the eventual goal, will sometimes guide the decisions made on which lines to include or exclude as outlines. It is

[96] The coordinates are: 792667, 2284665 (Projection system (in metres): UTM>WGS 1984>Northern Hemisphere>UTM zone 15n, the site itself is located in rectangle Q of this projection system). Although several GPS points were recorded across the whole of Chunchucmil, the inherent errors of GPS geolocation technology would add unnecessary uncontrollable errors in contrast to using the regularity of the calculable coordinates across the grid system.

important that for comparative purposes the level of detail can be achieved across the datasets concerned. The aim is to create a basis of equivalent spatial data.

Winchester base plan

Preparing an outline base plan on the basis of MM is less straightforward than its contemporary pedigree suggests. MM's aim as a mapping product is to satisfy policy and legal use requirements as well as depicting the physical layout of the built environment. It omits entrances to buildings, and many comprehensive buildings are represented by several polygons. It is unspecified how these compose an internally divided whole. This contrasts sharply with the way material information is conveyed by archaeological surface survey mapping. Here the *OS Address Layer* (version 2) will give an indication of the location and number of addresses at an approximate location, which helps the interpretation of the physical and social reality. Nonetheless, it cannot serve to generate aggregates of polygons which represent each building completely. Furthermore, MM keeps a record of a feature's development, extensions and adjustments, which adds further polygon confusion for understanding the empirical reality. In addition, MM offers a very basic and generalising degree of land use classification, and will often (but not always) indicate the provenance of a feature as either 'natural' or 'man-made'. At the same time most man-made open surfaces are merely described as 'multi surface' or 'general surface', which does not reveal much of what empirical reality is actually mapped.

This demonstrates that even when working on contemporary maps, rules of thumb are an absolute necessity for interpretively mapping a base plan. Given that MM records the contemporary situation, further information sources can be used to interpret the empirical situation represented. These sources are *Google Street View*, *Google Maps*, *Bing Maps*[97], and the *OS Imagery Layer* (vertical aerial photography). Although this can clarify a lot of what is represented in MM, including revealing minor discrepancies with reality on the ground, there are still aspects of the built environment largely inaccessible to us. These limitations mostly concern the backs of buildings and their gardens, small alleyways, or legally and functionally restricted areas. As remarked before, when certainty is required, only a dedicated urban survey might be able to fill in the gaps left

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[97] Online mapping and imaging resources can be updated without prior notice. The work on Winchester took place between May 2012 and April 2013.

after cross-referencing various sources, but this would go beyond the scope of this and most expected research contexts.

So creating outlines on the basis of MM involved intensive cross-referencing of the various sources — photographic sources being the most intuitive — to select the lines which firstly conveyed physically extant outlines only and secondly are not part of internal design or composite functions in an occupiable subdivision. In exceptional instances original MM lines received minor amendments to more precisely convey the actual physical difference on the ground and represent the topological connections accordingly. The greatest ambiguity is associated with separating buildings by internal divisions and, likewise, with complex plots and open areas around the back. *Ceteris paribus* the general assumption across the whole holds that in inaccessible areas all lines of MM would be physically recognisable on site. Therefore in principle they could all potentially be used to convey outlines. MM itself is topologically integrally developed by the OS in the GIS file format. Nonetheless, the tracing of lines in MM is a manual process, using ArcGIS editing tools. The result of determining outlines in MM is shown in **Fig. 7.3**.

Fig. 7.3: Example of the outline base plan overlaying MM
An example of the outline base plan (thick black lines) prepared on top of MM. The remaining grey lines (from MM) are not considered to be outlines as defined in my methodology. (Based on OS MasterMap. © Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service.)

Likewise, the georeferenced OS1872 introduced its own interpretive difficulties and ambiguities. Some of these are due to the two year publication period, which not only caused mismatches (see **Fig. 7.1**) between sheets, but also shows the city in development over time. Because the preparation of the base plan is a manual editing process, these mismatches were intuitively weighted to retain more or less continuous regular shapes (see **Fig. 7.4**). The image resolution and definition, as well as some detailed symbology of OS1872 made it unsuitable for using the semi-automated raster tracing in ArcScan, so the vectorisation entailed a manual redrawing of the lines intended for the base plan.

Fig. 7.4: Weighting the plan seam mismatch in vectorisation
The mismatch along the seam between map sheets, with the weighted shapes of the outlines shown in red. (Image prepared on originals: © Crown Copyright and Landmark Information Group Limited 2013. All rights reserved. 1872.)

Unfortunately, digitised historical OS plans are not delivered with a legend of the symbology and abbreviations used. Although Oliver (1993) mentions the existence of coloured versions of OS1872, these were not available via EDINA's Historical Digimap services. This explains the simple black-and-white line drawing shown in **Figs. 7.1** and **7.4**. This often makes it ambiguous as to what kind of (physical) distinction is represented by each single solid line. Coloured plans normally convey differences between built-up areas and open areas as well as to a degree the materials used (Oliver 1993). From comparisons between maps of the same era at the same scale (several can be consulted online at *National Library of Scotland: town plans and views* (undated)) and an extensive list of abbreviations used in various OS mapping projects over the years (also available online at *National Library of Scotland: OS abbreviations* (undated)), intensive studying of OS1872 leads to relatively accurate reading.

OS1872 was clearly aimed at a comprehensive representation of the physically present features of the city. The general resolution for detailing was 15cm on large-scale city plans (Oliver 1993), which displays greater architectural details than MM. In addition, functional furnishings of the city were often included. Strangely, contrary to Oliver's supposition, gates and doorways are not consistently featured on OS 1872, while archways (in walls) do appear. Vectorising towards an outline base plan thus involves selections and interpretations (e.g. excluding the furnishings and some architectural details, see **Fig. 7.4**). Similar to MM, accuracy cannot be guaranteed for areas around the back of buildings or within larger building complexes which are too compositely mapped to make certain inferences on what each line conveys. Likewise, separately mapped extensions were interpretively incorporated or divided into discrete buildings with internal divisions. Outbuildings are particularly complex as a great variety was used in the Victorian city. Instead of including each feature separately, clusters of outbuildings were given a single outline. Already having the outlines of MM to refer to, in manually vectorising OS1872 features that are tantalisingly close to MM lines were traced directly, which also retains consistency of data through time. When the shape and direction changes the MM lines were deviated from.[98]

Since 1550s was vectorised at the previous stage of the process, its base plan firstly comprises the merged data of the adjusted plot based and conjectured plan of Keene (1985). Due to the historically *self-selective* reconstructive mapping process responsible for this data and its coarse plot level of detail, no unnecessary or confusing detail is included.[99] The challenge for producing a base plan here is rather the reverse. The limitations of topographical reconstruction on the basis of the historical records (see Keene 1985; cf. Bisschops 2012) may cause unaffordable gaps preventing it from serving as an outline base plan. Most conspicuously, buildings are not mapped at all, except for those with public and administrative functions. More importantly, as the plans are property based, little certainty exists on the physical empirical reality of the lines and beyond a single property area, no further subdivisions are mapped. Therefore,

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[98] The Winchester City Council records mentioned earlier could only rarely (at the frontage) be trusted to convey a feature that could be historically projected into the past for OS1872 or 1550s.

[99] As opposed to archaeology (mapping all material remains) or remote sensing technology (detecting all physical features) of the actual situation, historical reconstructions are self-selective due to the restriction to a preconceived level of detail that is available and taken from the sources.

Keene's (1985) abstracts of compiled historical records on each property in his gazetteer are used to find clues about any multiple buildings, plots or gardens being part of a single property. Often the evidence for this is scant or even entirely absent (which is also the origin of some of Keene's own conjectures). This implies that a rather crude level of conjectural mapping is required to add the missing detail of the built environment to merge into a comprehensive outline base plan.

An additional source for conjecturing buildings onto the plots are Keene's (1985: Fig. 155) smaller-scale plans (per historical snapshot) indicating the built-up and probable built-up frontages along the streets. This is used to decide that a building needs to be conjectured. However, there is no pretention that the shape of a building reflects reality. Lewis et al.'s (1988) book *Medieval Hall Houses of the Winchester Area* depicts three examples of shops surveyed in the city of Winchester, which were between approx. 10 and 15m in length. These dimensions are taken as a rough maximum for typical buildings in the test area, next to comparisons with the more detailed knowledge of smaller separate properties along the High Street area. Without any readily usable direct sources grounding morphological intervention, ensuring that the topological distinctions were made was deemed more important than the appearance of buildings and garden plots.

To illustrate the coarse effect this practice has, **Fig. 7.5** shows the clear difference between the west and east sides of the northern end of current Chesil Street. The west features large subdivisions on sizeable plots, because no further evidence was available and the suggestion was raised that this area could have hosted a few substantial medieval buildings. The east, however, has been subdivided into smaller built environment features, because there was no special indication of substantial buildings and the one historical building still in existence (The Old Chesil Rectory) was indicated to feature two tenements with a probable communal arched entrance (Keene 1985). The neighbouring plots in that sequence feature frontages (probably built-up, according to Keene) with comparably dividable dimensions (4 or 5m each). On the opposite corner towards the north, there is an indication that at some point during the late medieval period there could have been six shops occupying this site. In these cases, the open areas behind the buildings are not subdivided as they could well have been shared.[100]

[100] Little is known about the actual (physical) subdivisions of open areas associated with buildings in the medieval period. Archaeologically there could have been fences, paths and hedges (cf. Becker's (2001) perishable albarradas), all used to section off small bits of space. In any case, it seems likely the

Open areas are only subdivided if prompted by Keene's (1985) discussion of the records.

Fig. 7.5: Crude conjectural effects in the 1550s outline base plan
The effect of crude conjectures based on scarce information on the material situation within the test case area. Dark grey depicts the lines based on Keene's original plan, pink the building and plot conjectures added. (Image prepared on originals, reproduced courtesy of the Winchester Research Unit.)

Although the conjecturing efforts ensure the same level of detail on a conceptual level — restricted by the self-selectiveness of historical reconstructions or fragmented archaeological records, but even the different nature of geographically representative city plans (e.g. MM vs. OS1872) — true equality in actual detail cannot be guaranteed. It would be a gross over-interpretation to start conjecturing absent outbuildings or morphological and architectural details. As a consequence, comparative work and analysis including more detailed sources should justify the simplified composition of other sources accordingly.

medieval city saw a variety of plot divisions and shared open areas (Dean *pers. comm.* 2013), which is also suggested throughout the discussion of properties in Keene's (1985) gazetteer.

Chunchucmil base plan

Since the Chunchucmil plan now exists as vector data, the process of creating a base plan is predominantly limited to tracing the appropriate lines with ArcGIS editing tools, as was the case for MM. Because by their very nature archaeological remains are fragmentary, straight away regular editing tools were used for conjecturing any apparent gaps in information (see below). First, however, tracing the lines determined to be outlines revealed structural issues with the data and the topological integrity of composed features. The compromised data structure most probably results from the initial drawing of the map in Illustrator.

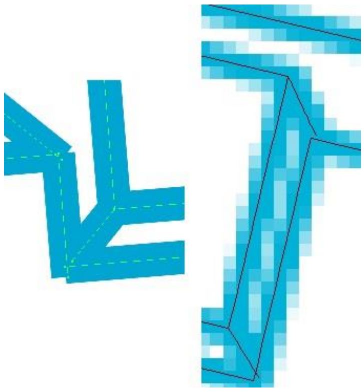

Fig. 7.6: Compromising native data quality in Illustrator and ArcGIS
Illustrator data (left) and converted ArcGIS shape files on top of raster image (right). (Image appears courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

Visually presentable figures in minute detail revealed line constructions that were unsnapped or simply did not match the features' geometry (**Fig. 7.6**). Effective tracing requires continuous (non-intermittent) lines. Despite measuring no more than a few centimetres or millimetres in geographical space, copying these errors by tracing would compromise the usability of the outline base plan. Therefore the process of tracing outlines required additional editing for cleaning up and sometimes completely redrawing features, ensuring a proper topological structure for the outlines; always represented by a single polyline. Similarly, mapped features in different layers representing two classifications of information (e.g. architecture and albarrada) would come conspicuously close to connecting, yet virtually never would these features truly connect. As a rule of thumb, detached mapped features of equal or different classifications would be connected (snapped polylines) within the outline base plan GIS layer if approximately under 80cm of width. Any analogous gaps of larger width or conspicuously positioned gaps would be connected in a separate conjectural layer.

After having traced all originally mapped features identified as outlines, conjectures were also used more progressively. These more progressive conjectures are intended to fill in the inevitable data gaps due to archaeology's fragmentary nature. Both to respect the theoretical foundation (see **Chapters 3** and **4**) and to enable topological spatial analyses, it is required that all the integral subdivisions composing the built environment are included as a base layer of information, avoiding any data gaps. As to date no other example of a Classic Maya site is known to manifest such a constellation of elaborate house groupings, pathways and boundary walls in the areas outside of the monumental centre (see Hutson et al. 2008; Magnoni et al. 2012), conjecturing analogically is largely out of reach. Therefore it was decided to follow a rather bold approach to conjecturing.

First, fragmented buildings would be finished continuing the shapes suggested in the observed remains. Second, fragmented boundary walls are completed exclusively with straight lines (without crossing any other tracings), directly connecting two ends of mapped lines of the same class or onto another feature, using parallel and perpendicular alignments (see **Fig. 7.7**). In the highly irregular and rounded urban form of Chunchucmil, straight lines will emphasise that these conjectures are not intended to represent informed *reconstructions* of the actual features' shapes. Instead, they complete the spatial data by restoring a close approximation of the expected topological relations that would have existed between subdivisions. While this unavoidably affects the morphological integrity of the data, suggesting actual morphological knowledge of the features amounts to over-interpretation. Conjectured information can always be retrieved as this is kept as a separate dataset (see **Fig. 7.7**). Naturally, if no archaeological remains at all were mapped, no additional conjectures are invented.

It is stressed that these crude conjectures are a requirement of the conceptualisations behind the boundary approach (as based on outlines of discrete subdivisions, **Chapters 4** and **5**). It is *not* suggested here as general archaeological practice and is not a necessity for each form of analysis and interpretation on the basis of the plan (as demonstrated in Magnoni et al. 2012). To ensure critical evaluation, the complementary conjectures went through three iterations. The initial phase concerned the coarse connecting up of features on screen. Then a revision was carried out based on the principle that directly or indirectly all spaces within an urban environment must be accessible to partake in the inhabited socio-spatial complex of the contiguous locus. This comes down to asking: how is one able to traverse the site respecting the actual physical barriers mapped? Uncovering this accessibility pattern was carried out on a high-resolution printout of the test case area with a semi-transparent overlay. The directing surfaces affording movement, flow and access to building complexes across the site were drawn. The conjectures were then adjusted accordingly to better facilitate or enable traversing where necessary. A final revision is a side-effect of the actual process of BLT identification (see below), which would point out any subdivision where a specific discrete outline was intuitively expected, but absent.[101] The particular relationship between virtual boundaries (**Chapter 5**) and conjectures is discussed later in this chapter.

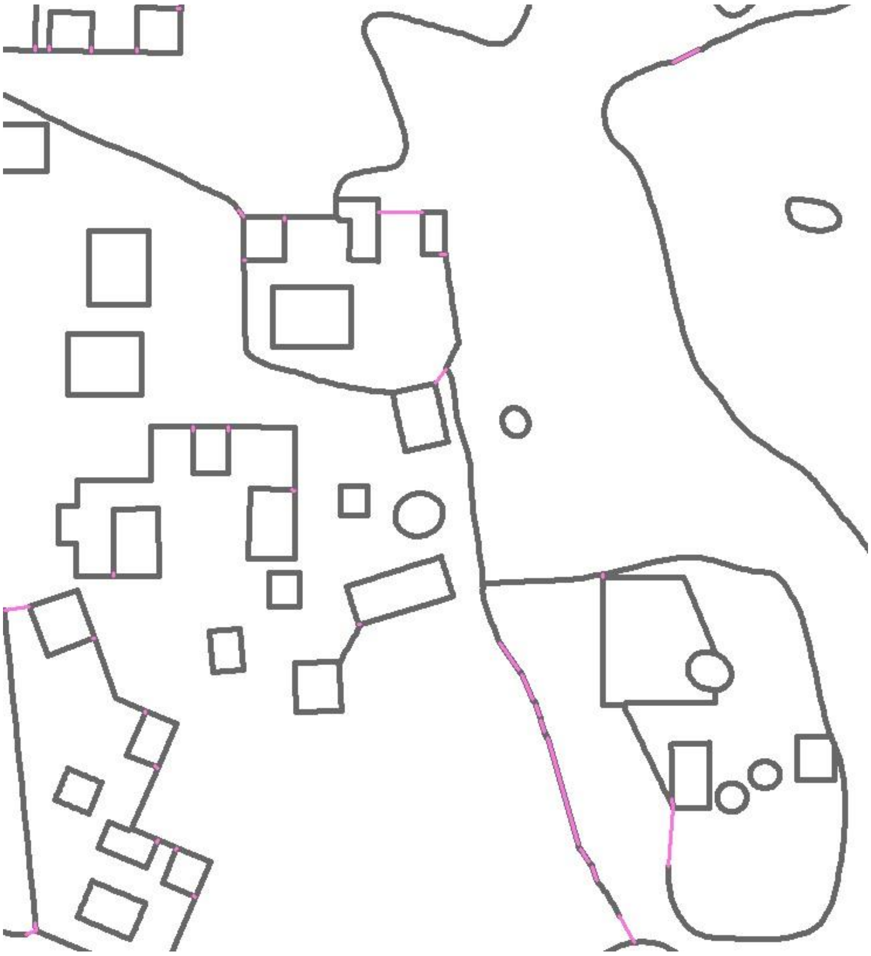

Fig. 7.7: Extract of Chunchucmil's base plan with conjectures
This extract consists of traced outline features (in grey) and minor and coarse conjectures (pink). (Image prepared upon original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

[101] All conjectures can be retrieved by directly comparing the traced data with the original plan. It is likely that more means will become available to improve and correct the conjecturing (or even a reconstruction) process in an informed way when additional research is carried out, giving further reasons to revise and adjust the current iteration and any analysis based on it.

In keeping with the outline logic, furnishing and internal arrangements as indicated by archaeological artefacts, stelae and quarries are generally discarded from the base plan. A quarry could only be (partially) included when it is suggestive of being incorporated as part of a built boundary. Querns or *metates* (grinding stones) within gaps in walls are taken as an indication of a probable passage way, because the arduous task of grinding in all probablility had a social element to it (Hutson *pers. comm.* 2012). Bedrock, however, is included as these outcrops of the natural soil would have impeded thoroughfare and are often incorporated in boundary walls and even minor architecture. It is a common expectation that various structures within groups of buildings could have been perishable (Becker 2001; Magnoni et al. 2012). The *chich mounds* (low piles of rubble) mapped on the original Chunchucmil plan have been suggested as having formed the foundations of (perishable) buildings (Magnoni et al. 2012). Indeed, the placement in association with building groups of (circular) chich mounds conspicuously resembles the round buildings mapped as architecture. Ancient Maya buildings do not typically straddle albarradas (Magnoni et al. 2012) and therefore, in revised iterations of the base plan, chich mounds with dimensions similar to round buildings and placed detached from albarradas are included in the base plan assuming they hosted a structure. In the rare instances where their situation within their surroundings is along the (albarrada) margins or their shape seemed illogically irregular for a structure, they are either excluded from the base plan or incorporated in another outline.

There are also ambiguities such as the ‘screen walls’ connecting structures in building groups in various Classic sites, mentioned by Becker (2001; Tourtellot III 1988). These could easily be confused with remnants of communal platforms and do often not form a discrete subdivision. In such cases the expert opinion of the mapmakers indicating where they identified a platform or group on the plan (by block annotations) is cautiously followed. Although Magnoni et al. (2012) offer a population estimate which is partly based on the count of residential structures (following the method of Rice & Culbert 1990), the boundary approach is based on only material-spatial information and cannot consider different structures partaking in a building group per function. Becker (2001) gives a good overview of what functional structures could entail, but also how few of them are systematically identifiable. In addition, various fragments of albarradas can also be found ‘dangling’ inside house-group-lots. Rather than creating actual subdivisions, these dangling lines may form part of internal arrangements in concordance with the activity areas and perishable boundaries mentioned above.

As a matter of critical research practice, all ambiguous features are initially traced as part of the base plan (see **Fig. 7.8**). Where a feature is clearly truncated by another feature, in the sense of being subject to modification of any type or having become obsolete, only the feature that appears to be responsible for the truncation is taken into account. There is too little knowledge about these architectural palimpsests on the basis of the survey alone to know the correct order or composition. The stage of identifying BLTs is again an interpretive process on the basis of the base plan. As said before, the BLT identification process may indicate where or how conjectures would be expected in order to complete a discrete subdivision. With this in mind all dangles or incomplete subdividing features remaining after BLT identifications can then be excluded from what becomes the actual final base plan. The researcher should always be mindful of the possibility that, consciously or subconsciously, readily perceived or concealed, subjective patterns could emerge from the underlying decisions and rules of thumb regarding outlines and conjecturing. The final base plan consists of tracings and conjectures of all the kinds described.

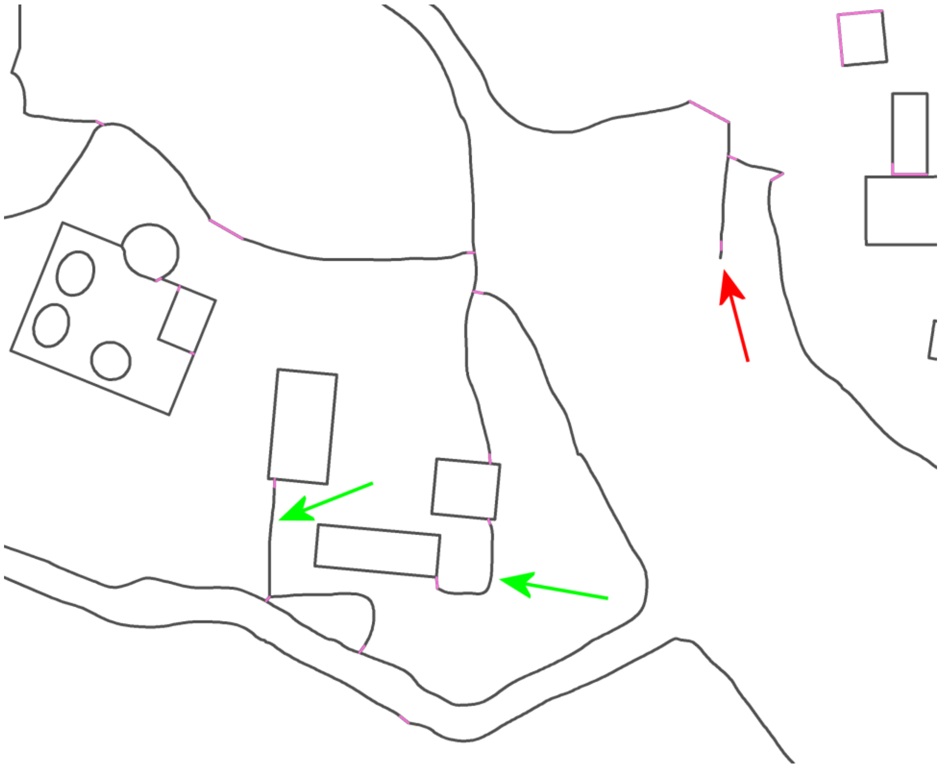

Fig. 7.8: Another example of the Chunchucmil base plan with conjectures (in pink)
The green arrows indicate incomplete subdivisions (possible screen walls), while the red arrow indicates what currently looks like a real dangle. Both situations will need to be decided on during BLT identification. (Image prepared from original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

Topology checks (3, 4)

As both outline base plans have been produced, a brief note should be made on checking the quality of the data created. Despite using the digital tools of a GIS environment, making the base plan is mainly a manual process and thus prone to imprecision and human error. Problems similar to the ones depicted in **Fig. 7.6** would inhibit the direct usability of the base plan data. BLT identifications in turn are based on manual tracings of the base plan, and thus require continuous lines in contiguous connections. This means that for the base plan to support this work effectively, one must ensure topological integrity throughout the dataset. To this end ArcGIS has developed the ‘topology toolbar’, which can carry out several data checks based on a predetermined topology rule set.

To apply the tools in the topology toolbar, it is best to merge any separate layers composing the created base plans into one comprehensive dataset. Then, within ArcCatalog any feature class (layer) in a so-called geodatabase can be subjected to a topological rule set. When the rules are validated, any found errors can be inspected and corrected within ArcMap. The first step of imposing topology rules is setting a cluster tolerance, which simplifies the data structure (i.e. any features below a measured threshold are regarded the same).[102] Then the rules themselves can be selected from options. Options include rules that help to make sure the data does not contain any unintended dangles, unsnapped vertices or nodes, intersections, unwanted duplication or coverages, unconnected polylines, etc. **Table 7.3** demonstrates the four relevant topology rules used for the base plan and as imposed to the BLT data (as described below).

Topology rule	**Outline base plan**	**All BLTs (except Type 2, Type 4, and virtuals)**	**Type 2, Type 4, and virtual boundaries**
Must not have dangles	X	X	
Must not self-overlap	X	X	X
Must not self-intersect	X	X	X
Must not overlap			X

Table 7.3: The selection of topology rules and how they have been applied

[102] Of course automated simplification is not ‘intelligent’. Though the accuracy is maintained to the resolution specified, at very large scales, some shapes will manifest counterintuitive alterations: e.g. right angles might have become slightly flattened and curves less smooth. Unwanted changes can be manually edited. Simplification will have a small mitigating effect on the earlier densification of anchor points in Illustrator (in the case of Chunchucmil).

Despite functional limitations,[103] this semi-automated process will speed up subsequent work and immediately improves the quality of any derivative data. When checking the errors found, any unfinished but ambiguous subdivisions kept in the base plan as well as all ‘edge effects’ (unfinished subdivisions truncated by the test area selection) can be marked as exceptions in the correcting process, while manual editing or automated fixes are possibly to resolve true errors. The cluster tolerance should be a measure commensurate with the precision achieved in the mapping resolution. For Chunchucmil 10cm was specified, which might be smaller than the actual mapping resolution achieved on-site, but which would retain most of the interpreted shapes (e.g. curves) as depicted in the Illustrator originals. For Winchester the cluster tolerance was specified as 5cm, which reflects the higher level of detail and precision in the MasterMap mapping as well as the features generated in the vectorisation processes of the other time-slices directly in the GIS.

As all boundary mapping is based on outlines, its GIS layers will always consist of polyline feature classes. The essential difference with the data structure of the outline base plan and each separate layer conveying a BLT (see below) is that *each polyline feature in the BLT layers must convey a BLT identification in its entirety*. In contrast, for the base plan the only truly important characteristic of the data structure is that, always maintaining topological integrity, all lines shaping the outlines are included. If the data resulting from the BLT identifications are intended to undergo any further computation for visualisation, spatial analysis, or conversion into other formats, then it is paramount that not only the outline base plan, but also the BLT feature classes are checked against an appropriate topology rule set (see **Table 7.3**). The difference between Types 2, 4, and virtual boundaries and the other BLTs is that the latter all circumscribe space. As polylines are a flexible format, this enables a further visual check of the data. ArcGIS proprietary tools can process polylines into closed polygons, making polygons, showing up as filled areas in ArcMap, which will not happen if the lines are not continuous or the ends not connected (snapped). Vice versa, the intricacies of the BLT data structure cannot be automatically generated from polygons. However, one should remain mindful that in complex data errors are easy to overlook. Furthermore, automatic creation of

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[103] Unfortunately, topology rules appear unable to handle composite rules regarding more than one feature class (layer) at once. However, they can run multiple questions simultaneously, each treating a single layer. Complementary coverages can be checked by using tools for selecting on location. It is also possible to set topology rules before mapping and check up on data created in a (semi) live way, whilst editing the data. This could be more efficient if most eventualities are known upfront. Likewise topological rule sets can be adjusted if it is found that the rules do not adhere to the intended logic.

polygons lacks human intellectual understanding, so inner and outer BLT designations can lead to separate polygons. Although producing polygons from polylines is an operation that enables further visualisation and can serve alternative analytical purposes (see Magnoni et al. 2012), this last issue requires a degree manual editing to remove intellectually unqualified polygons.

Identifying BLTs (4)

Identifying BLTs is the final and most analytical stage in the mapping process. Each instance a BLT is successfully recognised within the outline base plan, according to the definitions in **Chapter 5**, the segment of line is traced individually and entirely. This is a manual editing process in ArcMap, using the tracer in the editing tools. The result of this process is that each data entry (i.e. each polyline) created at this stage is a complete and meaning carrying empirical identification of the material socio-spatial reality of a specified boundary operation occurring at the (historical) moment represented by the city plan. For each BLT (**Table 7.4** lists the BLTs with name and number), including virtual boundaries, a separate layer (feature class) is created. This improves clarity whilst conducting the identifications and thus increasing complexity, but it also enables immediate visualisation of each BLT separately and can visually approximate combinations of them. In addition, if the boundary method would at any stage be combined with other methods or data, each separate meaning carrying data entry can be retrieved and invested with further information using attributes in the spatial database.

Although the order of BLT identifications is not prescribed, there is a logical starting point following from the principle of ontological primacy of seclusion. As discussed in **Chapter 5**, the formulation of the BLT ontology of types commences from the ability to close off (make impermeable) a bounded space (subdivision) towards undisruptive interaction from the outside, i.e. a strongly emphasised seclusion from within and necessarily ‘intrusive’ interactions from without. In its simplest form this creates a ‘cell’ with a relation to its outside (cf. Hillier & Hanson 1984), which here is represented by the material properties of impermeability of buildings. The initial BLT reading of the outline base plan thus is restricted to finding these materially *closable* outlines of an occupiable surface (not negative), extracting their socio-spatial system from the goings-on in their environment, i.e. Type 1. Again, this is not to say that Type 1s are a prerequisite for other BLTs to occur (see **Chapter 5**) (even though an urban built environment without Type 1s would be extraordinary) as the BLT ontology of types does not fully define their relations.

Boundary Line Types			
1	Closing boundaries	8	Mutual boundaries
2	Facing boundaries	9	Opening boundaries
3	Associative boundaries	10	Neutral boundaries
4	Extended facing boundaries	11	Man-made boundaries on unoccupiability
5	Directing boundaries	12	Not man-made boundaries of unoccupiability
6	Disclosing boundaries	13	Not man-made negative boundaries
7	Enclosing boundaries	V	Virtual boundaries

Table 7.4: List of all BLTs with name and number
For abridged definitions of all BLTs, please consult the supplementary BLT table in the back.

There is, however, the ontological necessity for Type 1s to require at least one Type 2 in order for the Type 1 to partake in the socio-spatial configuration and not become a negative void. A Type 1 without a Type 2 would become a Type 11 (negative), as its inside is not accessible for occupation. As this method is intended for built environments, especially in urban cases, the identification of any BLT implies the existence of others specifying the socio-spatial context. Hypothetically speaking, a configuration of only one Type 1 plus 2 would also be designated a Type 13 for the undeveloped surface area surrounding it (or the limits of the selected area of data coverage).

The singular seclusion of the dominant Type 1 thus becomes the first identifiable point of reference in an outline base plan, from where increasingly more of their environment can be inspected to identify further BLTs (see **Fig. 7.9**). This initial stage resembles mapping a figure-ground plan (see Trancik 1986), as one is essentially mapping out the built volumes from the open spaces (see **Fig. 7.10**). Such a figure-ground plan approximation can aid readability of the boundary visualisations.

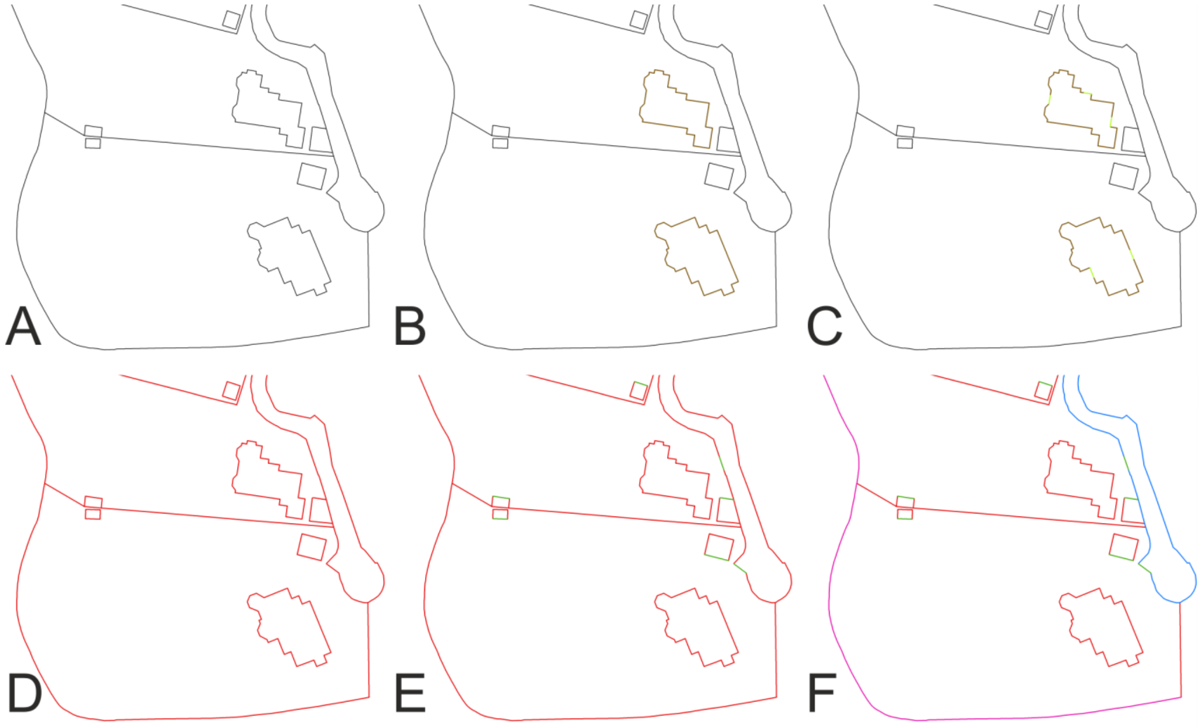

Fig. 7.9: A sequential representation of stages in BLT mapping
A composition of six consecutive images (left to right, top-down) of the same configuration showing BLT identification starting with (A) outline base plan, then (B) Type 1 (brown), (C) Type 2 (light green), (D) Type 3 (red), (E) Type 4 (dark green), (F) Type 5 (blue) and Type 9 (pink). (Derived from OS MasterMap. © Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service.)

It is clear that there is an important degree of knowledge beyond the lines in the outline base plan required (in Winchester's MM supported by aerial photography and online mapping products) to know that the geometrically rugged shapes represent buildings. There is an augmentative quality to the overall order of identifying BLTs that initially roughly pertains to the order in which they were presented in **Chapter 5**. In **Fig. 7.9**, Type 2 first qualifies the Type 1s. Then associative boundaries (Type 3) naturally encompass Type 1s, which in turn are made accessible by Type 4s. Then on a larger scale a Type 5 and Type 9 tie this configuration together.

Fig. 7.10: A figure-ground approximation of part of the Chunchucmil test case
By generating the Type 1 identifications as polygons an approximation of a figure-ground is achieved, which can aid readability. (Image prepared based on original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

There are several things to note about **Fig. 7.9**, which apply to BLT mapping in general. First, the consequence that no single BLT identification can fully define the material reality that is represented by a boundary line means that all BLT identifications overlay each other and thus situation F contains six BLT layers (with the BLT identification process completed the outline base plan is no longer necessary). Second, the entrances (Type 2 and 4) are partly conjectured, based on (aerial) photographic sources and the shape and size of the outlines. With such large buildings one expects more than a single entrance and entrances connecting the building with the morphology of its environment. Only a survey can confirm how correct these conjectures are. Third, Type 3s encompassing Type 1s (or indeed any other BLT doing the same) bound a space with an inner and an outer boundary that do not meet. That means that the two polyline features are part of (caused by) a single Type 3 identification. However, they do not concern the same boundary line. Once applied, the abstract character of BLT definitions reconfirms that in isolation they cannot capture the empirical reality. The inner Type 3 coincides with the Type 1, while the outer Type 3 coincides with other Type 3s, Type 5 and Type 9 respectively (disregarding the Type 2s and 4s). The combinations alone fully describe each unique boundary. Fourth, this composition shows a situation in which there are more architectural structures than only the main building. These auxiliary structures (outbuildings, follies, garages, sheds, garden houses, and many more functional varieties in other cultures and different historical periods, etc.) add a layer of subjectivity commanding the professional judgment of the researcher. Though accuracy in the decision can increase with additional knowledge or previous familiarity, it is a precarious interpretive decision which structure is the dominant or whether there are indeed more dominants.

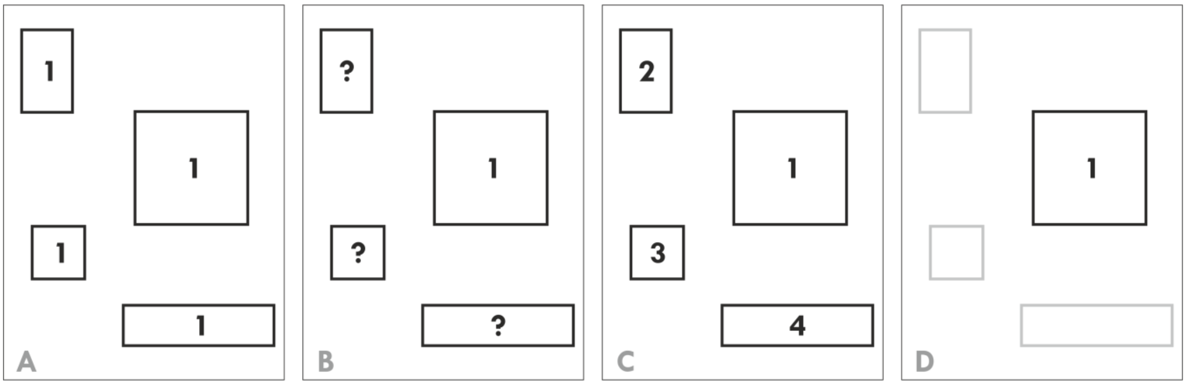

Fig. 7.11: BLT mapping of building groups
A: all buildings are a Type 1, thus the open area a Type 8. B: one building is designated Type 1, the rest remains unknown. This causes impossible data gaps. C: all buildings within a group need to be distinguished. This requires hierarchical and/or functional knowledge beyond (comparative) reach in spatial data. D: one building is designated Type 1, the rest discarded. This would mean losing a lot of architectural information.

As there would have been several ways (see **Fig. 7.11**) of approaching this last conundrum, the decision to determine the auxiliary buildings as a Type 3 needs some explanation. The term ‘auxiliary’ already suggests a relation of dependence and indeed what is alluded to here is the idea that a building is predominantly occupied with a socio-spatial system that may extend into associative boundaries. These additional Type 3s are strongly marked because of their architectural construction, which is chosen to be preserved rather than discarded as internal arrangement so if future work wants to distinguish architectural building types and/or functions, this could still be done. The current absence of evidence within the data prepared to be of most comparative use is not evidence of eternal absence of properties allowing further distinctions.

There are many cases in which a relation of dependence is not so clear, e.g. agricultural and industrial complexes or special housing groups of equally large of elaborate structures. In such cases the seclusions are validly deemed equivalent and all become Type 1s. This changes the relation between BLTs as instead of a Type 3, this would become a Type 8 (**Fig. 7.11**: A). Without additional knowledge this distinction will always remain somewhat arbitrary, often evolving as a practice based rule of thumb as one accustoms oneself with the patterns occurring in an urban tradition or within a case. For example, the internal comparison of material properties could lead to the conclusion that a farm *house* still bears closer resemblance to a town house than a farm *shed*.

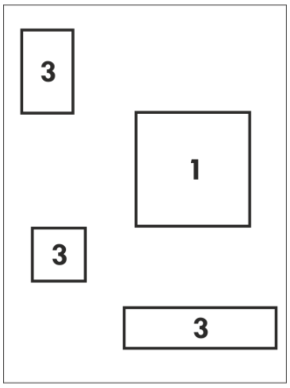

Fig. 7.12: Chosen solution to mapping building groups
This is the solution chosen for building groups retains further architectural detail, while restricting professional judgment to a more comparative binary distinction between structures.

However, the basic consideration as described here makes an important contribution to comparative work. Whereas the alternative of introducing hierarchical distinctions between architectural structures, as it were creating interrelated ‘dominant complexes’, sounds attractive, it creates false certainty (over-interpretation) about the way that structures are related, which would rely on equal additional information across datasets. Notwithstanding the interpretive character, the chosen solution (**Fig. 7.12**) retains additional morphological detail, while only making one main judgment on building groups without misleading detail or data gaps or reduction (**Fig. 7.11**). Maya settlements are characterised by a high frequency in grouped architectural structures. Although some structures might actually serve specific functions alongside e.g. a house, extensive research suggests that building groups would have been occupied by multiple nuclear families (Johnston & Gonlin 1998; Magnoni 2007). In Chunchucmil, for example, virtually all groups contain more than two buildings, meaning that with greater confidence these would likely contain more than one Type 1. The associated open areas in either case comparably end up as a Type 3 or a Type 8 constellation, depending on a one-to-one or one-to-many building(s) relationship.

Allowing additional Type 3s (or possibly Type 8s in other configurations) creates sequences of the same neighbouring BLTs. These distinctions might otherwise have been discarded as internal arrangements. However, retaining them initially gives the researcher greater flexibility later, as one could choose to disregard configurative complexes of interconnected Type 3s (or Type 8s), or one could focus part of the analysis or interpretation on the differences they convey. This brings us to a final point. From an intellectual point of view the BLTs that do not circumscribe a subdivision, but qualify the relation between two subdivisions, i.e. Type 2 and Type 4, should be traced twice, creating two polylines. Ultimately each entrance of a boundary is a qualifying part of each co-located BLT (e.g. the reciprocity of any passage or doorway). This would therefore duplicate identifications in such instances. However, for both visual and analytical purposes this is unnecessary in the spatial data. The length, construction and location of any such boundary could be recognised and utilised from the single identification. The same applies to virtual boundaries.

Virtual boundaries

Virtual boundaries have been briefly discussed in **Chapter 5** with regards to junctions of Type 5s (i.e. usually street junctions). Virtual boundaries are an intellectual construct that chimes with everyday understanding and interaction within the built environment, but which cannot be directly observed empirically. Contrary to all BLTs, a virtual boundary is an implied presence. The implication follows from the position in the context of the empirical material reality of built boundaries, which require a ‘virtual extension’ in order to connect up to create a discrete subdivision. That means that in the sense of Smith & Varzi (1997, 2000; Smith 2001) virtual boundaries are a fiat presence in a bona fide world. They are more restricted and less volatile than completely imagined boundaries, as it fully depends on the configuration of the material context. In **Chapter 4** it was already indicated that the gaps in built boundaries serving as (closable) passage ways (usually Types 2 and 4) would as feature outlines be closed to create discrete subdivisions. When differing types of open boundaries meet, they might equally be traversable via gaps where the surface material continues, while their circumscribing built boundaries morphologically suggest a distinction that would have been experienced (e.g. grass fields with partial fences). This is rather like the way marked space gives way to subdivisions of space (see **Chapter 3**).

While in contemporary maps it cannot always be determined whether such gaps existed instead of materially emphasised boundaries, in archaeology the number of virtual boundaries can be much greater, as gaps are mapped. It is rather likely that virtual boundaries are overrepresented as perishable materials could be used for doors etc. This implies a dialogue between conjectures and virtual boundaries. Basically a conjecture should fill in a missing material built boundary, but sometimes it appears that a virtual boundary would make more sense or is even necessary to traverse the configuration effectively. Virtual boundaries can resolve numerous dangles remaining within the outline base plan, while especially within archaeological situations they reflect some interpretive contention also.

In Chunchumil's case, it would be a logical expectation that there were (possibly closable) openings in albarradas which allowed people to access the areas they circumscribe. In the conjecturing process discrete outlines were possibly created also where these openings did originally exist. There is no way to distinguish on the basis of the mapped material remains whether any opening was intended, destroyed, deteriorated, caused by decayed perishables (e.g. incorporated cacti), removed (by animals or humans) after abandonment, etc. (Hutson *pers. comm.* 2012; Becker 2001; Demarest 1997). At the same time there is no real necessity for each wall or distinction to complete a circumscription contiguously. Indeed, in Chunchucmil several platforms tying building groups together would gradually descend into the ground, creating a ramp for probable unimpeded access (Hutson *pers. comm.* 2012). Virtual boundaries are thus used to mark-up situations in which it is likely that missing physical information would not have detracted people from contextually recognising the spatial distinction at that location. This enables further discrete subdivisions to be mapped (**Fig. 7.13**). Note, however, that although virtual boundaries would note places of unimpeded access, entrances (Types 2 and 4) do not require virtuality, nor do virtual boundaries occur on the basis of conjectures only.

As was said before, the BLT identification process might still cause changes to the original outline base plan. This is especially true for conjectures and those instances where eventually it is decided that a virtual boundary must exist or have existed. The most regular virtuals result from identifying BLTs, because studying the outline base plan according to their definitions would often indicate likely locations for virtual boundaries to occur. Those virtuals that connect up actual gaps in boundary lines or from Type 5 parallels would not have been included in the outline base plan. It can therefore not be assumed that the prepared outline base plan will contain all the lines as present within all BLT identifications and virtual boundaries taken together, while at the same time identifying BLTs and virtual boundaries might still discard some incomplete or dangling differentiations within the outline base plan.

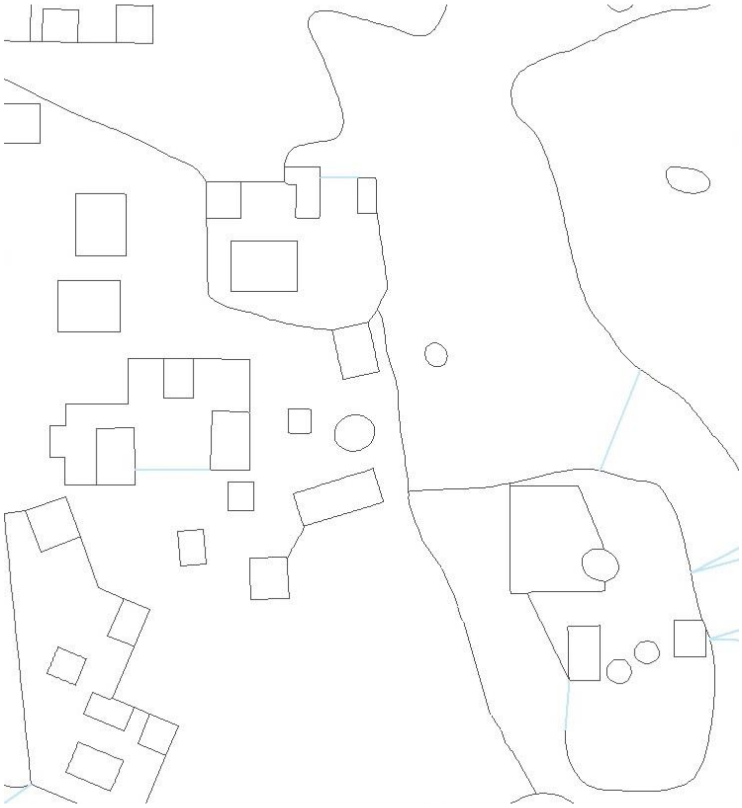

Fig. 7.13: An example of virtual boundaries in Chunchucmil
Chunchucmil's outline base plan (grey) with several virtual boundaries (light blue). The virtuals on the right hand side follow from Type 5s (see **Chapter 5**) and would not have originally been included in the base plan. (Image prepared from original data courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

Rules of thumb

Finally, while the nature of the data sources require a selection of case specific processes and the preparation process requires case specific decisions, these do not stop at the more generic level reached so far. It is stressed once more that despite their formal definitions (see **Chapter 5**), identifying and mapping BLTs is very much an interpretive process on the basis of an equally interpretive base plan. Their respective data creation processes even maintain a level of reciprocity, especially as the base plan is prepared with BLT identification in mind. Therefore, it can be expected that in practice, especially as one becomes increasingly familiar with the particulars of a case, rules of thumb emerge. These are used to resolve ambiguities and confusing data situations while identifying BLTs. As part of good subjective practice, reports on the research should make the reader aware of these more arbitrary decisions for data treatment.

The BLT ontology of types serves the specific purpose of enabling the study of the socio-spatial significance of the inhabited urban built environment and therefore disparate ontologies of the built environment might be necessary to study other aspects of its existence. The process of applying BLTs should not be criticised for the declared limits to analysis and understanding. Besides an immanent critique on the BLT definitions themselves, within the application of BLTs a logical immanent criticism would be to find fault with instances of identification. Additional knowledge and understanding of the nature of the originally observed and measured situation creating empirical data could in time lead to commensurate revisions of both base plan and BLT identifications. Yet, in keeping with critical realism (Sayer 1981, 2000; Yeung 1997) one could improve the boundary line type ontology itself according to unexpected empirical situations encountered within the process of identification. As I said in **Chapter 5**, this ontology is always open to necessary adjustment of types or even adding to the current boundary line types. In addition, one might be interested in retaining and accepting the data structures produced in this process, but combining it with other information directly by using the spatial database attributes. This alone might already enable the asking of disparate or more (socio-culturally specified) detailed questions than the remit currently pursued. The rules of thumb, however, give the researcher a remit of interpretive leeway on the basis of the empirical reality originally represented and subsequently prepared in the base plan. (This, in turn, could be critiqued for inconsistent application, being overly ambiguous, or simply a difference in professional opinion.)

The discussion below omits comprehensive illustration of all issues, as this would duplicate the preliminary analytical and interpretive presentations in **Chapter 9**.

Winchester

As Winchester represents a diachronic test case, there is one aspect particular to working diachronically that demands attention. This is to ensure that in the few cases where a boundary line would remain in exactly the same location through time (e.g. it was justifiably close to be copied from the later base plan), any *concurring* BLT identification on that location should be identical to the more recent phase. Doing this helps to keep the data clean by eliminating confusing insignificant differences. Most instances where this occurs concern historical building frontages, which also retain the same doorway. Unsurprisingly, due to data preparation processes such as scaling and georeferencing (see above), the base plans outlines rarely end up close enough. The upscaling of 1550s to MM alone causes scanned line thickness of 50-60cm in geographical space. **Fig. 7.14** demonstrates these issues.

Due to the style of OS1872, the nature of outlines often does not reveal itself clearly until the BLT identifications disentangle all the lines. Similar to the iterative revisions of conjectures on Chunchucmil's plan, the OS1872 base plan is therefore more invasively revised during the BLT identification process than is the case for either MM or 1550s. At the same time the additional architectural detail and pathways in parks and gardens, available on OS 1872 only, give an extra certainty for conjecturing any entrances.

The previously mentioned limitations to assessing the back of buildings satisfactorily mean there is little secure information on back entrances in each time-slice. In general the assumption is then made that back entrances are necessary for structures which have a plot around the back. Unless the shape and mutual orientation of the outlines and further identified BLTs suggests differently, the back entrance is conjectured broadly in opposition to the front entrance. Only in elaborate buildings and complex contexts or on the basis of additional factual information would more entrances be designated. It should be noted that because many entrances are conjectured (cf. Chunchucmil below) their dimension is less relevant than their existence topologically. The width of entrances is at best indicative.

Fig. 7.14: A demonstration of working with historical persistence in spatial data
The thick black lines show the upscaled 1550s scan. The grey lines represent the vectorisation process for the 1550s base plan. The blue lines form the base plan of OS1872 and the red the MM base plan (here building modifications). The green overlay the OS1872 entrances and the green underlay the MM entrances. The front entrances in the middle of buildings existed there in both MM and OS1872. (Partly derived from OS MasterMap (© Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service); original scans: © Crown Copyright and Landmark Information Group Limited 2013. All rights reserved. 1872; and original plans, reproduced courtesy of the Winchester Research Unit).

Working on urban built environments more familiar to the researcher means that there is a greater immediate understanding of what could be expected. This applies especially to outbuildings, garages, sheds, follies, etc. as discussed above. In contrast to Maya settlements where groups of buildings are justifiably identified as Type 1s, Winchester is an example of familiar western urbanism. Outbuildings are thus typically understood as auxiliary to and under the intended influence of the main structure they are in constellation with (i.e. the extension of a single socio-spatial system). It seems detrimental to go against that a priori understanding, which would have the consequence that most gardens become the socio-spatially distinct Type 8, despite understanding there is a single Type 1 determining the configurative complex. Outbuildings in MM and OS1872 are thus treated as sequential occurrences of Type 3s or 8s despite instances where their material properties are impermeable like closable solid dominants. The choice to regard the configurative complex as an indistinct whole in interpretation and analysis is retained for a later decision, maintaining comparative flexibility if e.g. MM and OS1872 had to be compared with coarse and fragmented historically or archaeologically derived maps. Indeed, this may be necessary for certain diachronic analyses comparing with 1550s as the latter lacks outbuildings. Moreover, it takes away the need for repeating the interpretation process entirely if the outbuilding information is desired later.

On MM, boundaries of unoccupiability (Type 11 or 12) are primarily based on MM's own 'natural' or 'man-made' classifications. On OS1872 they are based on the symbology on the original scans, and on 1550s they are limited to bodies of water only as no additional physical information is included in the test area of the self-selective historical reconstruction (see **Note 99**).

Garden plots situated like housing plots without a directly associated building on site are quite particular to the medieval period in the Winchester test case. Though justifiably identified as opening boundaries (Type 9s) they are something of an oddity. Their open character logically makes these gardens a Type 9, but the known function is quite distinct from parks or other open areas. This difference is similar to the distinction of an agricultural field and a park, which resonates well considering garden plots could have been used to grow crops rather than serving a more modern leisure function. Besides built-up frontages, Keene (1985: Fig. 155) identifies likely 'open ground', which seems to indicate land without any particular identified use, which roughly follows the general plot pattern. The limitations of the current BLT ontology prevent such functional differentiation. Functionally Type 9s thus have a protean referral record, somewhat reflecting the elaborate differentiations in urban studies (Stanley et al. 2012; M.L. Smith 2008). Although outside spatial-material reach, from a social perspective the ambiguity due to the lack of a predominant socio-spatial occupation could justifiably render any unused space (e.g. fallow) a Type 10.

Chunchucmil

As for Winchester, an initial rule of thumb is required for building entrances (Type 2). The nature of the archaeological map is such that from the piles of rubble and debris from which the mappers were able to estimate structures, it would typically not be possible to also define their entrances. This leads to the use of an analogical assumption by giving preference to buildings facing each other (directly and indirectly) as found throughout the Classic period in the Maya area in plaza and platform groups (see Becker 2001, 2004). Additional entrances may depend on any associated boundaries in their configurative complex (e.g. facing an open plot behind). Alternative locations for entrances are identified when the spatial context displays a persuasive measure of orientation elsewhere rather than the fashion of facing other buildings. Hutson (*pers. comm.* 2012) suggested that small structures in the middle of plaza groups could have been entered from any side as they could have served as elevations to address audiences.

As discussed above, in Chunchucmil all architecturally mapped structures and architecture (usually located in groups) have been identified as Type 1s (see also **Fig. 7.10**). This might include a proportion of what in western and globalised cities would be considered (functional) outbuildings (although many actual outbuildings could have perished also). This leads to an abundance of associated Type 8s and relatively few Type 3s, which is believed to reflect Chunchucmil's particular socio-cultural nature.

It could generally be assumed that platforms are accessible from all angles as they are low enough to mount without too much trouble. Similar to encountering a low front garden fence, however, it would be logical that there are preferred places to access a platform. In many cases the platforms have been mapped as if they gradually descend into the ground on one or more sides. This was confirmed by a detailed excavation of a platform group (Hutson *pers. comm.* 2012). Caution is indispensable as a discontinuous platform outline could have a number of other causes besides those of intentional architectural construction. When subsiding platform sides have conspicuous locations within their context this is regarded as an indication for places to ascend onto and access the platform. In instances where a full outline is mapped (possibly including a conjunction with albarradas), a wider opening between buildings or orientation towards the surrounding configuration is accepted as the indicator of an access way.

Architecturally, albarradas are regarded to be materially impermeable (although they tend to be lower than the human field of vision). Yet, they are usually open boundaries due to the conspicuously fragmented and often virtual nature of their course, which occurs even in well-preserved areas. Impermeability is thus permanently mitigated by probably wide and/or multiple passages. Only albarradas mapped over a complete circumscribing course could become identified as (closable) Type 7s (i.e.

enclosing boundaries). The same is considered for rarely occurring high platforms with an outer outline formed in conjunction with structures, circumstantially leading to a probable formal entrance.

The parallel definition of Type 5 is applied in a very flexible sense, sometimes including mirroring lines and contextually derived directionality. This means that two lines forming a relatively narrow (in context) but irregularly shaped corridor in a mutual linear orientation are likely to be identified as a Type 5, applying empirical parallelism broadly. Type 5s running long contiguous courses are rare in Chunchucmil (few streets exists). Deciding between a Type 5 or a Type 9 is subjective to the degree that the researcher needs to judge when the general observed parallel structure is sufficiently lost.

Though Type 6 depends on opening out onto several Type 1s, it is set apart from Type 8 because of its integration and sense of local centrality. It would seem that plaza and platform groups make good candidates for Type 6s, but usually their bounded area is spatially removed from the 'open' flows of traversing the site from anywhere within the spatial system. Generally identifying a Type 6 is closely associated with nearby or connected Type 5s and Type 9s, along which Type 8s, in contrast, would often be placed laterally.

Taking BLT mapping forward

When the processes in this chapter are enacted, the result is a complex GIS of immediately visualisable BLT data. Within the confines of this project this has only been done for the small test case areas as described. While the BLT mappings could be seen as a formal redescription of the urban built environment in socio-spatial terms, their increased complexity on top of the already complex morphology and topology only reveals further insights when focusing on tiny areas at once; figuring out which BLT combinations each space is composed of and its connections. In order to create better visualisations and greater understanding, appropriate tools are needed to rework and (re)order the created data. Therefore, the data structure that emerged through BLT mapping needs to be better understood. Moreover, thought should be dedicated to which analytical measures could provide meaningful results. So before we turn to a closer inspection of the specificities of the test case areas and what we may learn from the redescription directly, **Chapter 8** will explain the data structure and the opportunities for spatial analytical measures this enables.

CHAPTER 8 – REASONING THROUGH THE POTENTIAL FOR SPATIAL ANALYTICAL MEASURES AND VISUALISATIONS ON BLT DATA

Introduction

Now it has been demonstrated that the boundary conceptualisations can be operationalised by applying them in a mapping practice, in essence a data creation process is established. The specific purposive remit of this research has been developed in the first two chapters. By enabling a study of the inhabited urban built environment it is expected that a contribution can be made to the long term comparative understanding of urbanism on a human and social level. **Chapters 3** and **4** provided the specific understanding of the phenomenon that is thereupon implied and appropriate for study. The boundary concepts are a vehicle to make the socio-spatial information contained in the material nature of boundaries explicitly available to interpretation and analysis. While **Chapter 6** explained that various methods of analysis of the urban built environment and its history exist, none of these are commensurate with the current research agenda. Although the BLTs have been defined meticulously in **Chapter 5**, even setting out the extent and levels of interpretive value they incorporate, in order to unlock the intricacies resulting from their application in the previous chapter first a thorough understanding of the structure of the data is necessary. For without such understanding, it cannot be fully understood which data properties can support the interpretive reading of BLT mappings, nor can a rationale be devised connecting the BLT data to the levels of socio-spatial significance in **Chapter 5**.

Therefore, this chapter will first clarify the data structure that is produced by conducting BLT mapping, and introduce a way to visualise this beyond current capabilities within ArcGIS, including the computational difficulties of working diachronically. Then it will pre-empt listing analytical and quantitative measures by discussing the rationale behind using them. On the back of this understanding viable ways of questioning the spatial data commensurate with the interpretive values incorporated in the primary analytical units (i.e. BLTs) and their derivatives are considered. Especially for social scientists and humanities scholars GIS software evokes something of a ‘black box’ effect (cf. Griffiths 2013; Lilley 2012), causing people to steer clear of its computing powers, which are deemed impenetrable. Inevitably, this chapter too is necessarily dense and abstract, but by providing a thorough insight in the data structure resulting from a manual mapping process first and structurally making links to the interpretive purposes throughout, it is intended that researchers from such disciplinary backgrounds can come to terms with the analytical opportunities.

It must be stressed that many of the proposed analytical measures are hypothetical and thus require further research to become geocomputationally operational. When appropriate it will be indicated where foundational software development was sourced to put certain visual and analytical principles into practice in a GIS environment. Within the confines of this research not all identified potential could be demonstrated, but a number of accessible possibilities raised in this chapter will be explored with and without geocomputational aids in **Chapter 9**. In other words, this chapter lays the foundation for a much more extensive analytical GIS toolset on the basis of BLT data than what could currently be realised and therefore offers an analytical and interpretive guide for future geocomputational development. **Chapter 9** will present the preliminary advancements made with creating readable (visually intelligible) BLT maps and extracting and compiling information beyond the initial formal socio-spatial redescription of the urban built environment made available through BLT identifications. The interpretive merits of these advancements will be illustrated by the test cases developed in **Chapter 7**.

Understanding the BLT data structure

Revealing the data structure is best started by recalling **Fig. 7.9**. The consecutive coloured lines built up an increasingly complex picture, yet also conceal much of the layered structure in the BLT data. In the same chapter it was imposed that *each polyline feature in the BLT layers must convey a BLT identification in its entirety*. This means — an implication of their definitions in **Chapter 5 —** that each instance of a BLT identification should shape (circumscribe) a space, even though the single BLT identification is not the complete description of the emergent socio-spatially structured space. (Exceptions are the edge effects brought about by the delimitation of the areal extent of data coverage cutting off features and therefore any associated BLT identifications and Types 2 and 4.) However, looking at **Fig. 7.9** the vast majority of lines eventually *visible* do not shape spaces in a polygonal fashion, which is a logical effect of exactly co-located features presented in the layered fashion of a vector GIS. Although through the practice of BLT identification one will be aware this is the case (in fact, this aspect of GIS actually complicates an effective, comprehensive, and secure identification process due to the lack of immediate overview) it is worthwhile revealing the actual layered data structure after a completed identification process in an exploded view of a familiar example.

Fig. 8.1 provides such a schematic representation of spatial GIS data. The centre of the image is formed by a 3D representation of a terraced house on a street with a back yard. For clarity the neighbouring houses are not drawn. Although at ground level the roofing construction does not actually matter, the image so conveys the familiar material empirical reality of encountering a house; after all, it is the material empirical reality that is redescribed on top of the reductive and representational spatial data. This data is here conveyed as an outline base plan (in black). The section of the schema above uses the same colour scheme as in **Fig. 7.9**: Type 1 is brown, Type 2 is green, Type 3 is red, and Type 5 is blue. Here, the BLTs are represented in an exploded view of GIS layers as they would be associated with the situation of the house. The light grey guidelines show how the BLT features would be co-located in the GIS, and therefore reveal that as necessary and expected the Type 1 identification of the outline of the house remains intact. Naturally, the same applies for all BLTs in the constellation.

The lower section of the schema makes this a little more technical. It collates the GIS layers (the horizontal black hairlines) on top of each other, following the line of the street that meets the front of the house. The black rectangles represent the nodes (not the shape giving vertices) that are part of the spatial data representing the front of the house. These nodes are formed by start and end points of the polylines used to identify BLTs and the points where BLT identifications first meet and eventually depart (two or more BLTs following the course of a line do not render any vertices covered along the way nodes as well). Because the BLT identifications are produced by the tracing tool of ArcMap's editing options it is ensured that each node and arc is exactly co-located with the base plan and other BLTs. The effect of the nodes is that the front of the house is divided into three complete socio-spatial descriptions of sections of boundary line: the doorway itself, and left and right of the doorway up to the corners. These three emergent elements are all topologically distinct and thus uniquely defined socio-spatially structured boundary line segments.

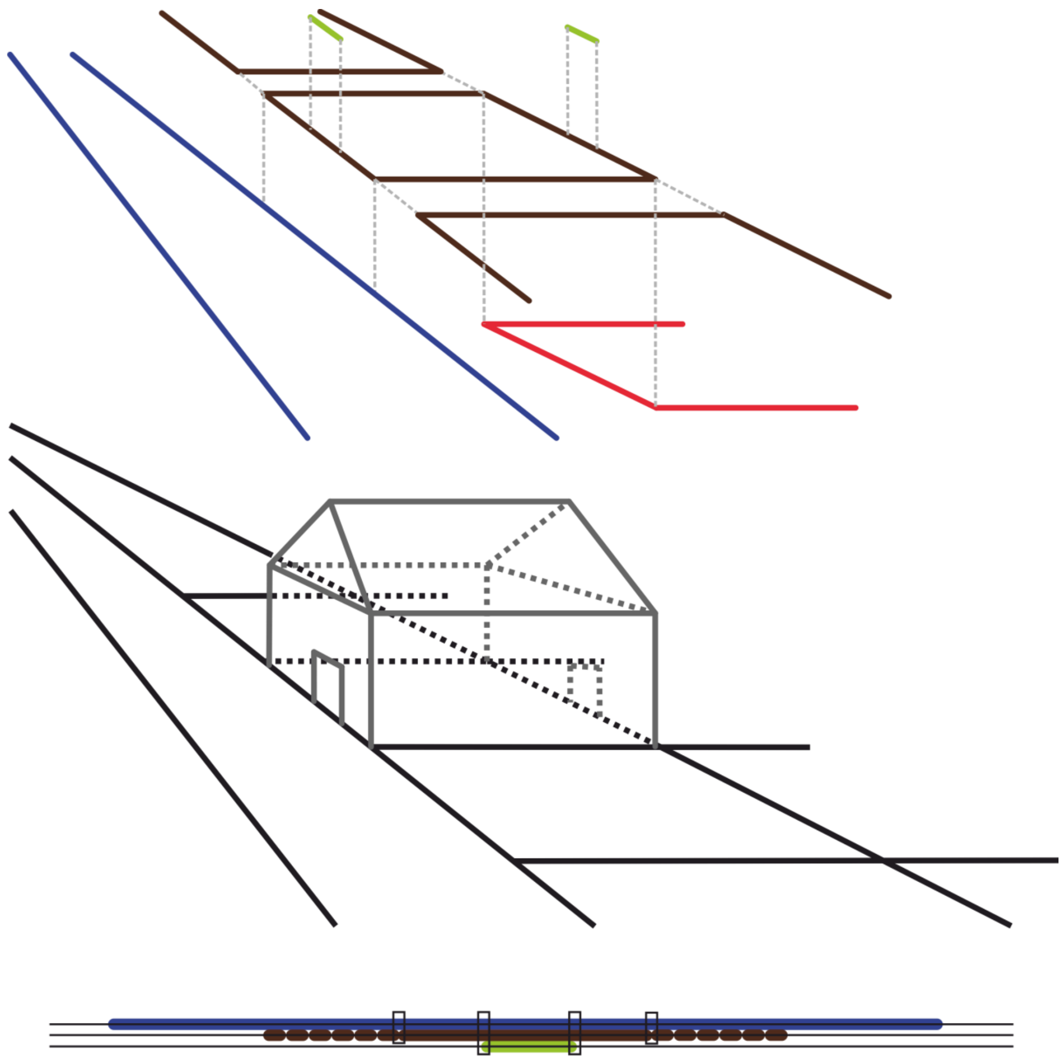

Fig. 8.1: Tripartite schematic representation of the GIS data structure
This is a tripartite schematic representation of the GIS data structure resulting from conducting BLT mapping. From top to bottom: an exploded view of BLT identifications; a 3D representation of the mapped terraced house; a schema of the data structure in GIS of the front of the house (see discussion below).

The following list formulates the distinct socio-spatially structured boundary line segments:

1. *Topological segments*: a topological segment refers to each unique instance of the persistence of a combination of BLT identifications along a segment of boundary line in the outline base plan;
2. *Boundary segments*: a boundary segment refers to any continuous part of boundary line contained in the outline base plan;
3. *Topological sides*: a topological side is distinguished as the occurrence of a continuous extent of a topological distinction of BLT identifications determining

the socio-spatial description of a circumscribed space from its outside. This allows any shape, including rounded shapes, to have distinct 'sides'.

The topological side differs from the topological segment mainly by excluding the topological distinctions emerging from Types 2 and 4. Scrutinising **Fig. 8.1** once more with these definitions in mind, it could be said that a topological segment, redescribing the front door of the house as a Type 1-2-5 combination, occurs along the topological side of the Type 1-5 combination. From the Type 4 definition follows that a BLT associated with a dominant is required to have a Type 2 within the topological side where the dominant and the associated boundary connect.[104]

Note how these definitions and this further understanding of the data structure allow one to divide the data in sections according to differing logic. These sections or analytical units can each inform and structure further investigation and interpretation of the data in their own ways. Moreover, depending on the purposes, these sections could be invested with additional appropriate information (attributes) for a fuller description of the concrete element. Only a topological segment, however, conveys the full socio-spatial redescription of any part of the built environment. That does not mean that each BLT in isolation is analytically completely devoid of use. It may actually be socio-spatially unintelligible as a boundary reference, but separate BLTs still circumscribe each subdivision as a spatial structure in its entirety (which is not the case for the structure of the lines composing the base plan). Therefore they can become a heuristic vehicle for investigating the BLT composition of subdivisions separately.

Finally, the topological segments, as unique instances of BLT combinations, form the *smallest meaningful elements* out of which the ontology intrinsic to each city (see **Chapter 5**) is composed. Their shapes and connection form the topological and morphological configuration, but now considered as materially present elements of socio-spatial significance for the (developmental) process of inhabitation. The entire

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[104] It should be noted that built environment contexts are thinkable where it is not an absolute necessity that a boundary associated with a dominant is disclosed directly by a Type 2 (entrance) to the dominant. For example, houses built on a slope could potentially have gardens which would be geospatially adjacent, but topologically detached, only to be accessible via a detour crossing unassociated boundaries. However, simply put, this only means that such topologically detached associated boundaries cannot be qualified with a Type 4 (extended facing boundary). That is to say, entering area circumscribed by the associated boundaries does not lead to an opportunity to cross into the dominant also. Only rules of thumb could cause erroneous (due to flawed or restricted information) identifications of Type 2s, since overall it would be a logical assumption that adjacent associated boundaries are disclosed by a Type 2. This also does not contradict that sequences of associated boundaries could have sequences of Type 4s. Additional functional, architectural, and topographic knowledge could support identifications of associated boundaries without Type 4s.

composite complex of the urban built environment consists of the total count and variety of the occurring unique BLT combinations, which gives an immediate (statistical) characterisation of any study area as a whole. So while the above emphasises mostly topological properties, it should be noted that the topological structure of BLTs concurs with the preserved morphological structure as initially represented in the subdivisions of the base plan. In this way the material and spatial formation of shapes and their dimensions remain within reach. Thus, by employing BLT mapping both topological and morphological properties are open for analysis of socio-spatial significance.

Visualising BLT data

The trouble with the usual layered visualisation method within GIS software is that co-located features are obscured. ArcGIS does include the option of semitransparency, but this cannot offer a solution here. The colours would immediately become confusing and any lines where the same BLT occurs twice would be indistinguishable. This clearly demonstrates the need for a better way to visualise BLT mappings holistically on a synchronic time-slice level. Such visualisation would enable the interpretive reading of the map of materially present socio-spatial elements at least providing a basis for intricately contextualised redescriptions of (aspects of) the urban built environment complex.

To this end a geocomputational Java plugin for ArcGIS was internally sourced as part of this research.[105] The hypothesised essence of this plugin's operation is to laterally displace the polyline features of each BLT feature class (GIS layer) with respect to the (segment of the) polyline feature with which it is co-located by the thickness of the line visualisation in ArcGIS proper.

Ideally the tool would expand the shape uniformly presenting each boundary nested inside each other consistently with noncircumscriptive entrances placed along the outside of the shape they specify. However, where two or more shapes meet the conflicts require detailed and complex rule-sets to enforce a geographically representative location and hierarchy which ensures that lateral displacement to the left or right prevents visual intersections of features. Such visualisation process should maintain the original topological relations and therefore requires the proportionate

[105] All programming and software development was executed by Andrew Evans, based on software specifications I stipulated, based on the theoretical treatise in this thesis.

rescaling of the morphology of each feature to achieve this nesting commensurate with the measure of displacement. In this way all BLT identifications would remain readable in their entirety as continuous polylines at once, thus essentially producing a BLT map.

Within the resources available for this project, the level of complexity to develop and programme this meticulous spatial visualisation rule-set was too great to resolve. Therefore, as a first-sweep geocomputational development a more accessible way to producing BLT maps at this stage was decided on. This retains the principle of displacement, but does so on a layer by layer level. This implies that intersections and disjunctions cannot be avoided, and that the shape of features cannot be rescaled. However, by displacing entire layers it would be possible to see all BLT data as individual identifications on a single time-slice at once. **Fig. 8.2** exemplifies this make-shift, but usable solution on the basis of **Fig. 7.9**'s data selection. **Chapter 9** will discuss the use and merits of such BLT maps more fully.

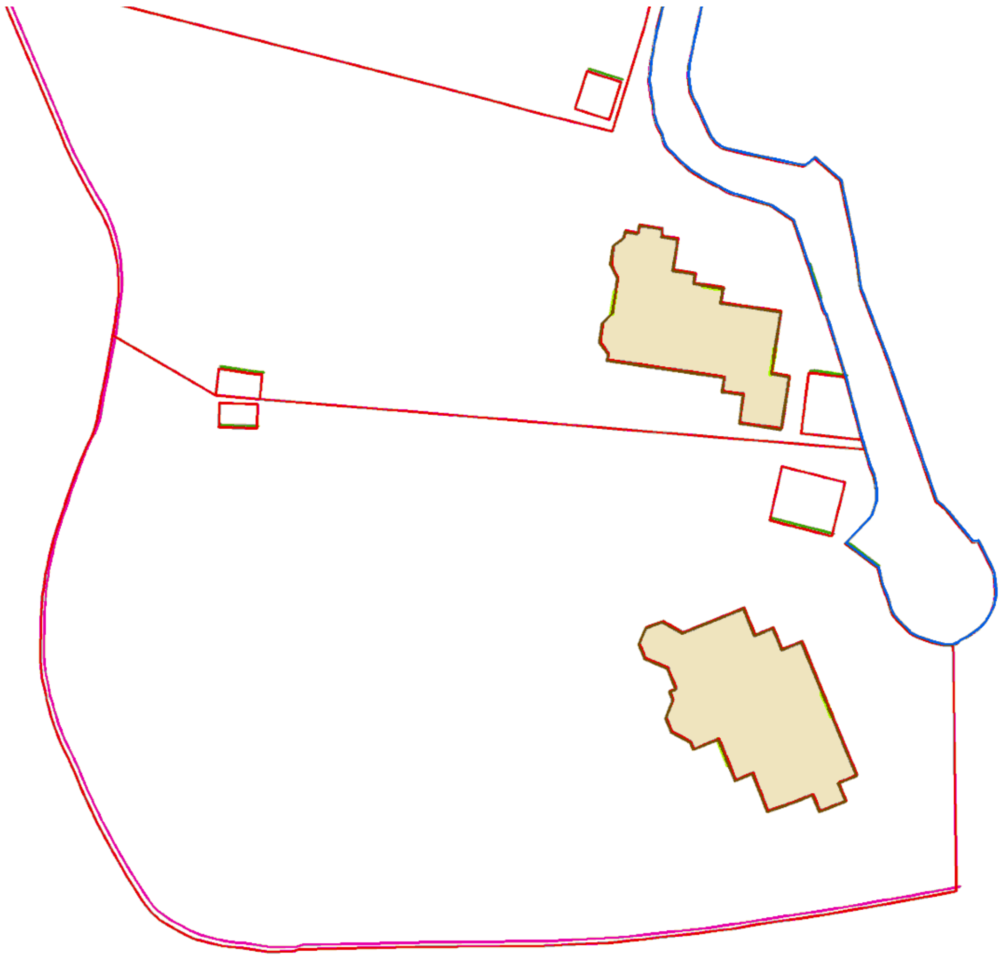

Fig. 8.2: Section of the BLT map for Winchester MM based on Fig. 7.9
Note how the lines show multiple colours following roughly the same (displaced) course. (Based on original OS MasterMap data © Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service.)

Diachronic data structure and comparisons

Conventional representations of the (urban) built environment would convey an image with readily recognisable socio-cultural or functional categories with a spatial expression regardless of the time period. The attempt to express and make explicit the socio-spatial significance of the material presence of boundary differentiations has the initial downside of complicating the conventional image of the built environment. The ontological primacy of seclusion causes the illusion that perhaps BLTs could be seen as an alternative to such socio-cultural categories, but the precise socio-spatial assessment they enable is merely an analytical and interpretive stepping stone. Where a synchronic situation might still allow for an intelligible visualisation of a colourful jumble of lines, a diachronic multiplication of the thirteen BLTs would end up in a muddle even if 26, 39 or more distinct shades would be used.

Fig. 8.3 demonstrates that despite the advantages of vector data for spatial clarity the diachronic image of three outline base plans is simultaneously perceptively very complex. It is much easier to see quite specific relations between the time-slices than would be possible with the usual historical GIS application of semi-transparent overlays of raster data (see **Chapter 6**; *Tokyo Cityscape* (Amherst College, 2009); *Paris Cityscape* (Amherst College, 2010)). Vector data offers enhanced flexibility to pinpoint and distribute data of events or inhabitants from social history by connecting these directly to spatial data features, which then become immediately contextualised by the relative socio-spatial position of the material boundaries now associated with that information. Nonetheless, beyond focusing on small areas to untangle these specific relations, it is still very difficult to get an overall impression of the development processes from the vector data. If this is true for the relative simplicity of the sequence of three outline base plans, it is wishful thinking that much could be done by eye alone when all thirteen BLTs are switched on per time-slice.

This means that for effective diachronic analyses we require the aid of geocomputational tools. In **Chapter 7** some attention was paid to preparing the base plans for the time-slices and the identification of BLTs across different time-slices. It was declared that the extent to which the composition of the built environment's features should coincide is a matter of interpretation, where the most recent period (MM) is used as the most accurate mapping available. Uncritical projection of mapped features into the GIS layers of the past, however, is exceedingly contentious on the basis of the limited and disparate documentation available. As a consequence a practice was adopted in which only features that ended up in tantalisingly close locations to each other through time would be copied from the more recent period's base plan. Within the BLT identification process, this implied that where boundary segments also retained exactly the same BLT identification, this should be ensured to be identical, so as to not introduce confusing discrepancies due to manual work (**Fig. 7.14**). In practice this means that the spatial data contains many near matches that never truly coincide.

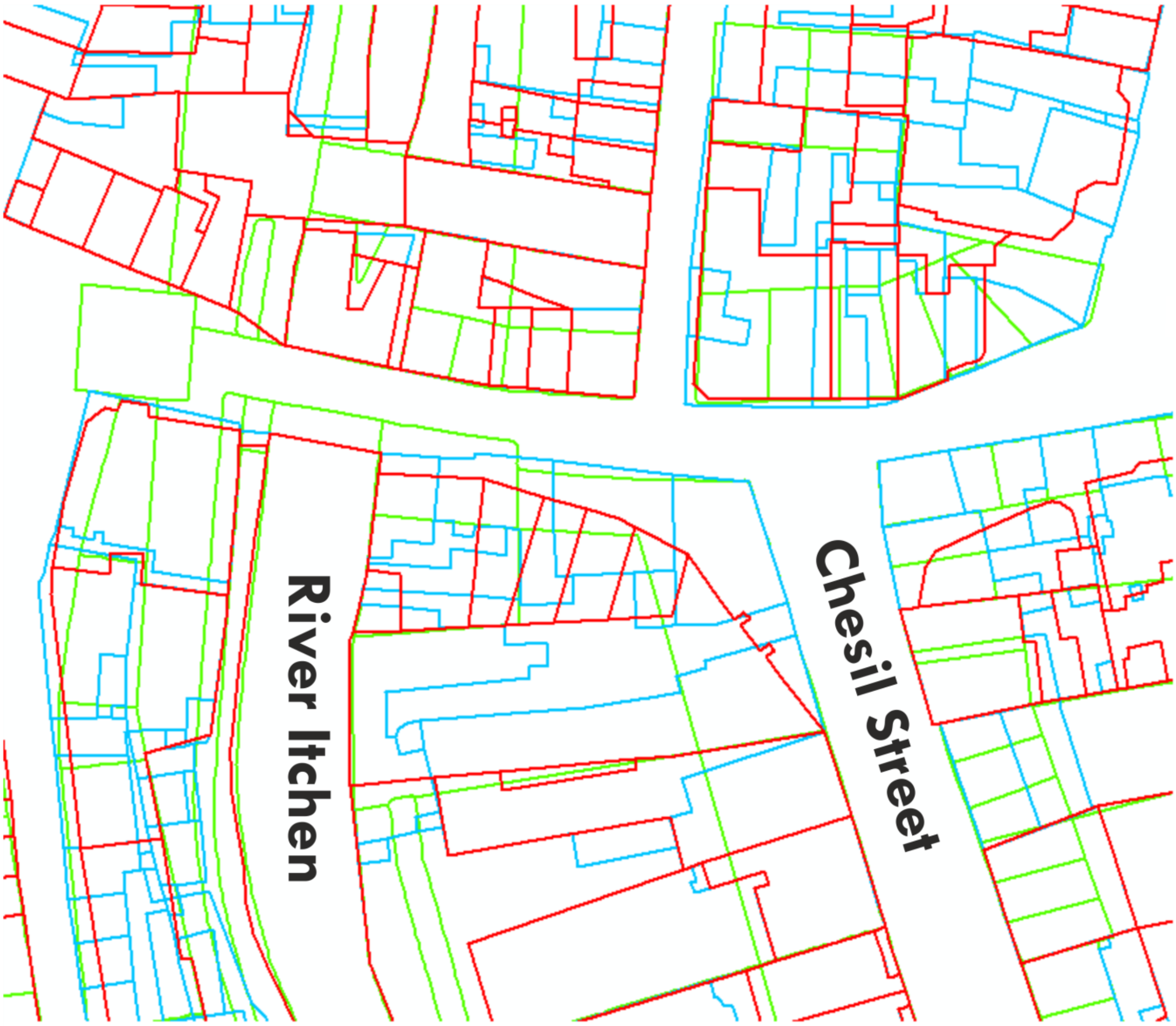

Fig. 8.3: The Winchester historical layers of outline base plans simultaneously displayed
These are the Winchester outline base plans overlaid for the test area: MM (red); OS1872 (blue); and 1550s (green). The major changes from 1550 to 1872 are formed by the removal of the city wall, widening of the bridge, and the intensification of built-up space, e.g. along the river. The major changes from 1872 to the present concern infrastructural adjustments to street lines, some major new buildings and cleaning up the mishmash of development along the west bank of the river. Some of the plot boundaries along Chesil Street are amongst the most persistent features. (Partly derived from OS MasterMap (© Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service); original scans: © Crown Copyright and Landmark Information Group Limited 2013. All rights reserved. 1872; and original plans, reproduced courtesy of the Winchester Research Unit).

The implication of this is that in comparing and analysing diachronically, any spatial analytical tool needs to work with a buffer zone as any feature that the human mind would regard as sufficiently similar to be seen as a continuation or match of the same necessarily differs in computational terms. Similarity and closeness in computation are typically a much greater challenge to detect and determine than intersections and exact matches. Moreover, similarity requires that *how* things are similar is defined. As described before, in the case of diachronic analysis there will usually be a mismatch between the geometrical compositions of two time-slices, of which part could still be regarded as the same persisting boundary lines. This means that by incrementing chosen similarity variables a cut-off point should be found below which things are generally regarded the same rather than the result of deliberate physical (urban) development.

Although the outline base plan may convey a comprehensive line drawing depicting the shape of all the subdivisions within the urban built environment (**Fig. 8.3**), the data structure of the base plan is fully contingent on the editing practices, tracing and vectorising, that produced it. That is to say, its separate features do not impart any specific intellectual meaning as GIS data. Furthermore, the base plan also may contain superfluous data that has not been taken forward in BLT identified subdivisions. At the same time the BLT identifications themselves as separate polyline features would only compare on a feature by feature basis, meaning that only similarities and differences of the entirety of the BLT identification to BLT identifications in another time-slice could potentially be detected. The first consideration, however, is to compare the existence of boundary lines between two time-slices. That is to say, is a boundary line either co-located or in the (very) close vicinity of a boundary line in another time-slice. Rather than any meaningful predetermined unit, this then refers to the existence of a materialised site of differentiation across two moments in time.

So rather than the composition of the polyline features created for either the base plan or the BLT identifications, similarity between the existence of any part of a polyline in one time-slice to any part of a polyline in another needs to be detected within a buffer (cf. Pierce & Weiss 2010). The best imaginable way to start such a process is with merging all BLTs into a single base plan corresponding to all eventually identified subdivisions and to explode the polylines composing that layer into the straight line segments (i.e. the smallest possible boundary segments) between vertices (the points shaping the polyline). Then create a buffer zone along the path of each straight line segment (see **Fig. 8.4**). In this way the existence of any other line segment falling (e.g. for a percentage) within the buffer zone (including intersecting the source line segment) could be detected. Any line segment cutting the buffer should be excluded as this indicates the boundary line is moving farther away. Subsequently the detected line segments should be compared for the orientation (in degrees from cardinal north) of the direction of their path, selecting those that fall within a margin of tolerance for deviating from the source. A further complication is then that the buffer might be significantly larger than each line segment in an intricately shaped base plan. Especially in (semi-automated) vectorisation processes or tracing processed Adobe Illustrator data, some tiny elements of ruggedness could become incorporated in a polyline. Therefore a minimum length per line segment should be set below which a dramatic difference in orientation should be disregarded.

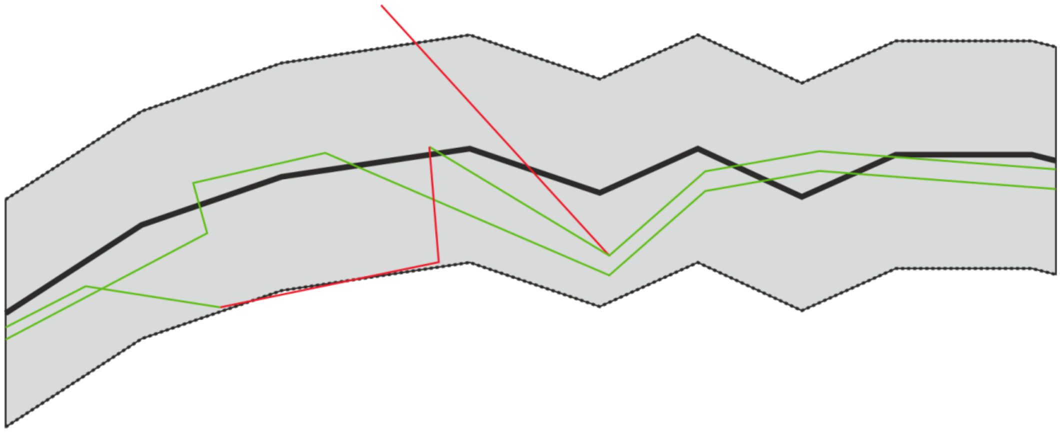

Fig. 8.4: Computational hypothesis for historical polyline data change detection
A fictional source polyline (thick black) with a buffer zone (grey), with potentially similar polylines: the green line segments fulfil the similarity requirements; the three red ones do not.

Having on the basis of the above selected the features that are sufficiently similar, all instances of consecutive line segments that remain similar between the two time-slices should be selected. This selection of boundary segments (from the base plan) can then serve as the basis to index the BLT identifications that intersect or coincide and the topological segments that co-locate with the historically persisting boundary line composition. The differences in the BLT combinations between the topological segments so detected in both time-slices and the way they are connected can start revealing the deeper socio-spatially significant patterns of rhythm, transformation, construction, removal, change and recurrence, in urban development. Chronological depth is achieved by pairing two time-slices in succession. On this basis further software development could assist in creating visualisations to express kinds of persistence and volatility through time.

Unfortunately the problem of comparing the composition and geometric shape of vector topologies in a GIS environment has no definite solution, but some development has taken place. The most promising direction for measuring the differences between two datasets of polylines is at least in part based on a geocomputational implementation of the Hausdorff distance, which basically measures how similar two geometries are (which in practice usually means how close all nodes and vertices of one dataset are located to all nodes and vertices in another). This is currently being developed to include extended buffers (Min et al. 2007) and topological connections (Li & Goodchild 2010, 2011). Software solutions have been developed to measure Hausdorff distances,[106] but these are not readily available as ArcGIS tools. Implementing this would be beyond the scope of this research. The current purposes focus mainly on conflating divergent datasets on the same phenomenon, whereas here we are after change detection, and except for the same area of geographical space (see an applied diachronic example in **Chapter 9**), it is not a given that the spatial datasets convey essentially different versions of the same information.[107] Furthermore, an appropriate way to approach similarity measurements, following the suggestions for variables made above, needs to be determined before Hausdorff distance measurements can be developed accordingly. It remains an interpretive decision when changes are deemed large enough to be ascribed to urban development as opposed to possible error margins in georectification and vectorisation preventing proper co-location between boundary lines.

While the above stringently depends on accessing geometrical and locational data in comparison across time-slices, we are not left completely empty handed. The results of any analytical measure that can run for a separate synchronic spatial dataset can be systematically compared for different time-slices (see below). Furthermore, it is still possible to use an image as **Fig. 8.3** to locate areas of interest and manually investigate the more specific combinations, layout, and connections between BLTs and topological segments. This more laborious and limited manual practice could still serve as a basis to incorporate (attribute) further social historical information to the more intricate composition resulting from BLT mapping, which would not be possible with modern

[106] Examples of such solutions can be found online at *ST_HausdorffDistance* (undated), and *JTS Topology Suite* (undated).

[107] ArcGIS itself does offer a tool to detect changes made to the editing of features and symbols in different versions of a map with Layer Snapshot tools (*ArcGIS Resources: Identify feature changes between map editions* 2012).

maps (see Bisshops 2012) and the visual relations more restricted on historical overlays. The novel conceptual data structure in this research thus only offers a first step in questioning and elucidating very specific society-space relationships in the past (cf. Griffiths 2013) and its socio-spatial processes through time. Developing better geocomputational tools will support the rigorous comparison of the socio-spatial structure of the built environment through time and so enable a study of the social materialising processes of the mutual constitution of the city and its inhabitants and the effects of urban planning and development. In that sense, only diachronically is the constitutive significance (incorporated by means of the theoretical framework in **Chapter 3)** as it is realised in the long term revealed, while synchronically this is restricted to the constitution of frames for speculative opportunities, delimiting how actual events or activities are accommodated (cf. **Chapter 6**).

Understanding proposed analytical measures

This section introduces the second part of this chapter, which hypothesises an array of potential analytical measures on the basis of which analytical tools can be devised. Before the opportunities identified from reasoning with the resultant BLT data structure are presented, this section will explain why and how working with (experimenting and exploring) quantitative measures can be meaningful above and beyond the intrinsic interpretive value already contained in the BLT identifications and BLT maps (formal redescriptions) themselves.

BLT mapping demonstrates the socio-spatial conditioning and contextualisation of encounters and interactions that could take place within the specific structure of the materially emergent location. The potential for movement or any other use and development opportunities becomes qualitatively characterised for each occupiable location and its relative socio-spatial position within the configuration contextualised by the formal socio-spatial redescriptions of each subdivision. While this may narrow down likely functions within materialised spatial settings (cf. Sayer's (2000) spatial independence), the probability of a particular activity occurring within a specific space is not assessed (see **Chapter 6**). Instead, BLT mapping is just limited to *making explicit the (affording and affecting) conduciveness of the materially present characteristics of the differentiations making up the built environment*. However, the intricacies of the characteristics and properties as they emerge from BLT mapping can only readily be revealed on larger scales (across whole urban built environment complexes) with the aid of computational spatial analysis.

Moudon (1997: 8) said that "all morphological analysis is carried out for the purpose of theory building." Insofar as that means hypothesising, the analyses proposed here serve the same purpose. Descriptions and explanations (the how and why) of the social signature and influence of inhabiting a particular built environment on urban life and development could be hypothesised by assessing the analytical outcomes of such spatial analyses. On the basis of an evaluation of the functioning aspects of urban built environments that are desirable, it could also serve to hypothesise an informing or, to some extent, prescriptive theory of city design. In a diachronic perspective, or with knowledge of executed plans in urban development, hypotheses could be formed about the impact of urban planning interventions and/or structuring power relations as well as comparing normative designs to their emplaced lived effects.

It applies to all purposive options, however, that whatever analytical measure is devised to produce the outcomes upon which interpretive and explanatory hypotheses can be built, it should be ensured to be meaningful in the light of the theoretical framework and the associated interpretive realm of the levels of socio-spatial significance: dimensional, locational, and aggregative context (see **Chapter 5**). Building interpretations and hypotheses is based on careful explorations of the characteristics of the large and complex datasets created. Focusing on the redescription of the urban built environment reveals simple relations and compositions on a local micro-scale, while operationalising the levels of socio-spatial significance through spatial analysis can further a deeper constitutive understanding of the ontology intrinsic to cities and across multiple scales. Rather than the outcomes producing deterministic insights, appropriately designed computational tools aid these *interpretive explorations* by extracting patterns, rhythms, and compositions of interconnectivity, position, and variety, coherent and heterogeneous aggregates, persistent similarities and marked changes, etc. inherently present in any urban built environment. While there might be an enormous variety of spatial analysis that could operate on empirical properties alone, within the study of the socio-spatial significance of material presence to the process of inhabitation, any analytical measure needs to be able to make sense (be comprehensible) theoretically.

The boundary data structure itself has morphological, topological, and geometrical characteristics, while eventually still representing a geographical situation. All aspects of these empirical properties can in principle be used for spatial analysis. However, deciding which analytical measures could result in interpretable results depends on the availability of a *theoretical grounding* for isolating empirical properties within the BLT data structure. As resources to develop analytical tools will always be limited, this consideration should guide research efforts instead of the fact that other empirical measures could be taken. So the question that needs answering is whether the selected property of the spatial data structure is quantifiable to the benefit of appropriate interpretive analyses? Only then it can be argued to serve a constitutive socio-spatial understanding of the material presence of boundaries for the processes of inhabitation pursued in this study.

All potential understanding we can get out of the data is already invested in those data. Indeed, the practice of BLT mapping might already have led to a different and better understanding of certain socio-spatial patterns particular to the case study. Some of the rules of thumb (see **Chapter 7**) express a crude initial understanding of the built environment revealed by being forced to work within data constraints. While the constraints of the levels of socio-spatial significance guide us to potential measures, and each spatial analysis accordingly could yield results that further understanding and inform hypotheses, their application is not predestined to always produce useful or intelligible results. Although eventually only some preliminary computational functionality can be developed and tested for its interpretive merit here — developing a full-fledged analytical toolkit is outside the scope of the current project — experimenting alone can determine its true value. In other words, the following approach to selecting analytical measures balances being fully experimental with all possible empirical measures and completely predetermining which analytical measures will produce useful results. The risk of ineffectual techniques or meaningless outcomes cannot be completely precluded and is concluded only by forming inferential arguments on their basis.

Space syntacticians (see **Chapter 6**) recognise and face similar problems of spatial data complexity. The topological possibilities of constructing a configuration in a limited grid can already be beyond intellectual grasp (see Hillier 2007). The situation at hand is mirrored by Franz & Wiener (2008: 577), who limit their efforts to the spatial properties of the isovist as devised in space syntax:

> “[...] the mathematical combination of a few basic isovists and visibility graph measurands results in a multitude of further description variables. The meaning and relevance of such descriptors are difficult to estimate a priori. A brute-force analytical approach is

> practically unfeasible, and, moreover, it severely increases the risk of producing statistical artifacts. On the other hand, cautious conservative correction methods based on the number of comparisons might completely mask effectively existing effects."

This effectively means that research faced with such a problem, though having the luxury of arbitrariness and experimental freedom, will have to decide on a rationale to restrict and direct research efforts.

The analytical agenda within *applied* space syntax has taken away the original potential of it acting as an analytical theory and therefore development has concentrated on very particular configurational aspects (an 'access topology') of its spatial ideas. Recently Marcus (2007, 2010) has developed an approach to measure what he calls 'spatial capital'. Here he goes some way to further qualify space syntactic analyses to open an ideas exchange and integration with urban geographical and urban morphological analytical measures, e.g. plots and buildings. The space syntax concern with *accessibility* is connected with *density* and *diversity*, e.g. access to density and access to diversity, which leads to improvements in the evaluation of the economic exchange-value and use-value of areas in urban complexes. "Although not all needs require high spatial capital, on the most fundamental level this seems to be what cities offer: the support of the generic need for people and societies to access differences as a means for social, cultural, and economical development." (Marcus 2010: 39) Marcus suggests space syntax should expand from its narrow definitions of experiential space (notably convex space and axial lines) to incorporate legal spatial notions of plots and properties, which when captured in those terms would serve assessment of economic resilience afforded by urban space. Marcus' ideas connect well to the analytical measures that will be proposed here. Yet, the emphasis remains on the socio-spatial interactional potential and experience of the material presence of e.g. plots, properties, buildings, and public spaces. Importantly, however, here too accessibility (restricted and enabled by boundaries), density of features (creating differentiating opportunities spaces at various scales), and the diversity of built differentiations (across the whole urban built environment complex and any subsets) make an important analytical basis unifying the affects and affordances of urban form.

Franz & Wiener's (2008) solution to direct and restrict analytical effort is an 'intermediate' theory-driven approach directed by exploration, which is exactly what is being proposed here. The following section of this chapter will employ the levels of socio-spatial significance — the dimensional, locational, and aggregative contexts (see

Chapter 5) — to select and inform quantifiable measures which can be derived from BLT data.[108] Analysing these measures marries the empirical identification and the interactional operation of the presence of boundaries as captured in the BLT definitions with the simultaneous interplay of the 'territorial', 'regulative', and 'entity adherent' aspects of these interpretive levels.

Finally, the implication of employing the levels of socio-spatial significance as resultant from the theoretical framework and the BLTs is that analytical outcomes cannot be interpreted beyond these confinements. Although each particular analytical measure might give more prominence to any single level of socio-spatial significance, this does not contradict the continued relevance to the others. The rudimentary understanding brought about by analysis will be in terms of the complete theorisation, but not reproduce it as the data particulars are intrinsic to each time-space specific case. The specific meaning and value of analysis cannot be foreseen.

Analytical information in the ontology intrinsic to the city

Because here, before anything else, the BLT data is analysed, the origin of all analytical tools is being able to access and present the structure and topology of BLT information (see **Fig. 8.1**). The first step therefore entails recognising the co-locations and connections, the count and combination, of BLTs relative to one another.[109] Such information would give the overview of how many and which BLTs co-locate with any other, as well as how many and which BLTs are connected to each. Although of interest in terms of basic statistics of the entire dataset, this overview might not be particularly intelligible. However, broken down heuristically per BLT and predetermined BLT combinations, it could support interpretations based on the visualisation of the initial redescription of the urban built environment emerging from BLT maps as discussed above (some exemplification is presented in **Chapter 9**).

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[108] A keen reader would find several concurrences between the 'measurands' used by Franz & Wiener (2008) and the measures presented here. It is stressed that while to a large extent coincidental, this is part explained by the similarities in the nature of the data used. Franz & Wiener's aim is, however, to improve the theorisation and congruent definition of measurands for space syntactic isovist analysis, which is disparate from the analysis of the interactional potential structured by the material presence of spatial layout in which human visual perception plays an *indistinguishable* role.

[109] Accessing the same inventorying information for arbitrarily defined boundary segments or geographical areas within which BLTs are located would be desirable to increase flexibility, but would require the manual creation of a boundary segment or area, because these are not inherent to the data. The same limitation applies to the analytical measures below.

An important improvement is the associated recognition of topological segments (as discussed above, the smallest meaningful elements in the dataset formed by unique BLT combinations). The tool involved will detect, or ‘section’, the BLT data as each individual topological segment. In this way, the topological segments would essentially produce a new classification of full socio-spatial boundary descriptors and their relations to each other. Although the total number of unique topological segments is potentially huge[110], the expectation is that, even though hypothetically an incomprehensible number of co-located combinations of BLTs would be possible, the constraints within the BLT definitions would keep the variety at a relatively manageable level in each real-world case. This variety together with the number of occurrences of each and the variety and number of their connections is a quantitative expression of the socio-spatial signature of a city (or the ontology intrinsic to a city). When each variety of BLT combinations and connections is expressed proportionately (i.e. in percentages) the resultant values may be used comparatively, e.g. as an ordinal ranking, including the magnitude of the differences between their proportional stakes.

An initial geocomputational tool was developed in-house, which indexes this information across a data selection in its entirety (i.e. as if the selection were a specific unit or entire city). **Chapter 9** will briefly discuss the first results this gives. The next still hypothetical step would be to literally dissect the original BLT data according to the topological segments and make each kind of topological connection selectable. Both the spatial distribution and the variety of topological segments and the occurrence of topological connections could then be visualised geographically. Subsequently, topological segments could be used as *derivative analytical units, i.e. the smallest meaningful elements*, further specified and selective spatial analyses. Without being able to dissect the data, all analytical measures based on topological segments below will remain hypothetical.

This indexing of topological segments can include the virtual boundaries, even though these should not influence the BLT-combination-led statistics expressing the ontology intrinsic to each city. Virtuals can be used to better understand the extent of the effect of visibility and preservation issues with the original empirical data acquired onsite (or using remotely sensed technologies) as well as distinguishing between data

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[110] A tentative approximation of the minimum number of possible combinations is given: taking combinations of two types out of the thirteen available, stipulating that the order in which the two occur is not double counted (13*12 over 2 = 78), but double occurrences of a single type are possible (+13 = 91), with two types (entrances) only occurring with either one of two possible others (-11-11= 69). (Virtual boundaries are not counted here.)

structures of equally well-preserved situations. That is, distinguishing a relatively informally shaped from a more stringent physically enforcing urban built environment (notwithstanding that socio-cultural rules concerning actual use and function could be equally strong in both instances). Calculating the percentage over the total length of topological segments and/or their proportional presence in density counts (see section on distances and density below) will indicate something about the extent and the kind of role virtual boundaries play.

Proposing analytical measures: dimensional context

From the dimensional context it is immediately clear that size and extent across geographical space matters. Interpersonal distance setting and territoriality as well as appropriate sizes for certain activities and their interactional negotiation, will influence at which distance to each other boundaries will occur and thus how large the subdivisions are that they form. The first quantifiable measure therefore considers the distance between topological segments.

Distances and densities

The distance between all topological segments is best approached by measuring and visualising densities over Euclidian space using algorithms which include a method of inverse distance weighting to produce a ‘heat map’ of how many or how few topological segments occur. Inverse distance weighting does not only count points across a radius, but takes into account how close a point is to the starting cell. For this the centroid (midpoint) on the polyline of the topological segment could be used, which implies that usually (assuming most built environments are composed of series of relatively convex spaces) fewer points can be expected when the length of the topological segments is larger. In principle the way to interpret such heat maps would be to regard higher values as more intensely differentiated built up space, implying more intense encounters between socio-spatial systems. It allows making the distinction between (areas of) settlement with propinquity to let socio-spatial systems reside spaciously or restrictively.

A logical starting point would be to try calculating such densities per arbitrary unit, such as a hectare (i.e. differentiations in approximately a 56.42m radius). However, it could be more interesting to select a surface value that has a relative meaning to the data. This could be the largest subdivision available in the case study area or the average surface area of Type 1 (closing boundaries being the strongest inward looking extraction from the surrounding environment). Using such values gives a view of the differentiation across the entire case area that is directly related to the largest occupiable area without further differentiation or related to an average of the strongest seclusions. Such relative measures are preferable for comparative studies as *ceteris paribus* a built environment with larger shapes will necessarily avoid high density of boundary differentiations.

This distance measure could subsequently be used to include the diversity of the topological segments occurring in the heat map. The diversity of topological segments leads to an insight into the heterogeneity (complexity) of the socio-spatial differentiation across space. The less diversity in the topological segments the more monotonous and equally conducive an area can be expected to be. Similarly, densities could be calculated for any particular BLT combination. An easy example would be the density of entrances. At the same time difference in the density of the same topological segment indicates probable socio-spatial diversification of the kind of interactions that is structured locally. Ideally the computational tool used not only visualises the density pattern, but makes it possible to select and thus inspect the individual features in ordinal classes of density. In this way the characteristics of the occurrence of absolutely measured density patterns themselves can be studied in the locational context.

Essentially all analyses on boundary diversity and characteristics here link the dimensional to the locational context (first and second level of socio-spatial significance). The gradual plot of a heat map is fundamentally a display of clusters of higher and lower density across specified surface resolutions. This therefore directly relates to the aggregative context (third level of socio-spatial significance), creating a specific persistence and coherence in the occurrence of differentiation which would have been part of emplaced lived experience. Exploration in the aggregative context can lead to further discoveries by conducting density analyses to identify emergent heterogeneous or homogeneous areas within an urban built environment or to describe the pattern for the entire complex. The first allows internal comparisons across space and the second comparison between cases. It is through comparison internally or across cases (or time periods) that interpretive rigour moves beyond redescription towards (constitutive) insight.

Lengths and sizes

Density is not the only way to let the dimensional context inform analytical measures. While possibly being the most abstract distance, a geometrically more complex analysis could consider the measured minimum distance one would travel from a specified topological segment to another, while remaining within a single subdivision (i.e. respecting the shape of the bounded space). In this way, for example, an indication of the distances from the entrance to a building to the entrance of any of its associated boundaries would be revealed. More complex questions could address how one would reach an entrance to a dominant configurative complex from an open boundary that partakes in the circulation system. These are ways into discussing the absolute distances between relatively public and private (more and less secluding) areas.

Simply inventorying the lengths of all topological segments will flag up the longest lengths expressing a strongly continuous particular relation between two spaces. Relating these to the lengths of separate BLTs could help uncover more particular relations. How often does a BLT identification become differentiated with different BLT combinations relative to its length? This would indicate which BLT operations are most prone to socio-spatial volatility and constancy and of what kind, thus placing the occurrence of particular BLT operations in internally and externally comparative perspective. Further, cases where the longest lengths often include materially impermeable properties could in context indicate segregating qualities to how spaces can be occupied. If the longest lengths often involve continuous Type 5s this indicates a relatively strong enforcement of certain directional interconnections within a built environment. Combining the density counts of occurrence across space with the relative density of topological segments along a BLT identification's length will indicate which BLT operations might, due to their especially protean or volatile nature, play a causal role in high densities. **Chapter 9** briefly introduces a geocomputational density tool (sourced in-house) to measure the average length of a BLT that can be *expected* per square metre calculated over the rectangular area of the total data selection, and gives an example of its use (regarding Type 6) combined with the density within the rectangular area including all occurrences of a single BLT. Ordinal ranks based on percentages of such a measure make heuristic use of the BLT as a primary analytical unit, giving an indication of the relative importance of each BLT operation in constituting the subdivisions of the built environment.

Using the BLTs as a heuristic vehicle, the surface areas of subdivisions involving a specified BLT serving to structure interaction opportunities in its own particular operation, could be compared to other subdivisions to produce a sense of the relative influence that is exerted by such particular differentiation within the system. At the same time by only allowing specific topological segments to co-locate with each subdivision formed by a particular BLT, a more local and contextually relative influence of the BLT operation can be revealed. Note that classifying merely the absolute measures of surface areas resulting from subdivisions would substitute an analysis of space[111] for an analysis of boundaries. Such a measure could become interpretable within the conceptual boundary framework when combining differences in size with the topological segments involved in composing them. As topological segments qualify and constrain the interaction opportunities that occur in space, it can be of interest if particularly structured space can be related to relative sizes of their persisting influence. While not based on geocomputation **Chapter 9** will provide an example of making this last possibility explicit on the basis of a Type 6 operation in Chunchucmil.

Constitutively speaking the distances, densities, lengths and sizes are the result of territorial distance associated with societal negotiations, activities, personal and cultural 'territorial' patterns (see Hall 1959, 1968). This includes exerting power and control across space, but is still distinct from how power and control is exerted, which is not always about dimensions. It also allows initial understandings of how particular differentiations across space are related, which can interpretively be related to how territoriality in various instances is expressed, including characterising it with mitigating boundary operations. The calculations related to density and size proposed here, produce absolute measures that only start making sense in relation to the occurrence of BLTs and topological segments as intentionally placed/built in space. Despite being structurally related in theory to Hall's proxemic principles, it cannot substitute for the exactitude of the regularities in absolute radii of interpersonal distances.

The measures suggested through the dimensional context are open to additional analysis through time. This would seek to compare and determine the processes in which the scales of boundaries develop, change, or consolidate, and whether certain

[111] There are many opportunities for combining this with additional information sets on e.g. architectural volumes and activity areas as well as alternative conceptualisations accounting further for the social significance of size.

BLT operations increase or diminish their claim on space, or how distance could be used to increase or diminish socio-spatial relations as part of urban development.

Proposing analytical measures: locational context

The locational context shifts focus on the occurrence of boundaries (thus, constitutively how they came about) to the specific interactional interfaces, thus the characterisations of the differentiations (what boundaries do), in space. The section above already demonstrates that the interpretive value of the analytical outcomes is not tied to any single one of the levels of socio-spatial significance. In the same way, the locational context implies additional analytical measures, which when applied could be of relevance to all levels. The focus below lies in particular on the restricting and enabling qualities of boundaries following from their general (material and contextual) characteristics collated as topological segments as well as in localised contexts. While the analytical measures presented in this section are all hypothetical, **Chapter 9** will engage and demonstrate the tenets of the interpretive merits of slimmed down versions of some of these measures (excluding orientation) on the basis of extracting and explicating patterns visually by reading BLT maps.

Topological segments in context

Dimensional contexts can become particularly empowered by the interplay with the material property of *impermeability*, physically enforcing the secluding performance of boundaries by being closable. Closing off from the outside at will, even if this is not (fully) enforced at all times, is an important social marker framing interaction opportunities and how interaction comes about. When closability forms a dominant boundary, the presence of boundaries associated with dominant boundaries nevertheless increases mutual interaction opportunities in relation to the socio-spatial systems occupying the closable space. This works in a mutual way: the dominant boundary extending its (dominating or claiming) influence and the boundaries associated with it ameliorating the severity of the seclusion. Boundaries in direct association with a dominant operate as intermediaries, part warding off and part inviting interaction.

This observation regarding dominants indicates a wider concern with analysing the diversity of topological segments in the locational context. Here the analytical measures address more specifically the context rather than the space (dimension) within which different topological segments occur: where and in which (surrounding and connected) contexts are topological segments located? Here we would be looking to reveal the role and prominence of topological segments through their contextual distribution across built-up space. As this is expressed in distribution patterns, any persistence and coherence of patterns over areas extends this analysis into the realm of the aggregative context. The interpretation can be supported by their proportional stakes in the overall diversity of topological segments and in relation to particular others. This can be tied to density measures also. From uncovering how specified topological segments are relationally positioned, the socially dynamic composition of occupiable subdivisions and areal aggregations becomes intelligible.

Concentrating on dominant BLTs on a local level as an example, in Hillier & Hanson's (1984) terms building up a configuration from a single spatial relation, we can address the socio-spatial characteristics of dominant configurative complexes. Where (geographically) and in which situations are non-dominant boundaries directly associated with dominant boundaries? What is the socio-spatial composition of thereupon emergent configurative complexes? This can initially include indexing the number and diversity of associated BLTs and topological segments, which can be presented on an ordinal scale, and subsequently the distribution patterns of particular complexity in diversity or number. A further specification may consist of the sequence of associated boundaries and how they are connected to the outside.

Linking configurative complexes up with the dimensional context, the distance from (relevant) topological segments involved with a dominant BLT to the maximum and/or average extent of the associated boundaries becomes an appropriate analytical measure. This gives a quantitative expression on the extent of mutual interactional influence, which if placed on an ordinal scale can be used comparatively. Emphasising the characterising focus of the locational context once more, this can extend into a circumscription of relative dominant influence. How many topological sides does a dominant configurative complex have and what boundary operations form them? That is, when and what kind of boundary operations restrict which dominant configurative complexes from the outside?

Orientation

The qualifying aspects of the locational context can also be expressed in a specific morphological way. This is the principle of *orientation* brought about by the shape of boundaries. Orientations reveal preferences within the morphology of the urban built environment leading towards interaction opportunities, with a particular emphasis on whether and how these are *restricted and enabled* by the characteristics of the boundary concerned. The principles set out below would permit the manual measuring of degrees of orientation, but recurrent and reciprocal patterns in orientations would carry the greatest significance. (This would include e.g. temples all symbolically facing the same way or avoiding certain directions for environmental reasons as well as neighbours facing each other or, instead, concealing entrances from the street.) Full consideration of this would need yet to be developed geocomputational functionality, while simple reading of BLT plans may immediately give one a general impression.

This is again anticipated to be especially relevant in relation to dominants and configurative complexes, particularly the mutual orientation between closing boundaries (Type 1) and the directly surrounding composition of the environment. Such relations are primarily characterised by entrances (facing and extended facing boundaries, Types 2 and 4). The orientation of boundaries is perpendicular to the overall direction along a boundary's length (between start and end point) (see **Fig. 8.4**) and could be expressed in an axis in degrees from the map's north. When relevant, the measurement should include detecting on which side the dominant BLT lies to differentiate an axis in an inside-out or outside-in facing orientation (i.e. from the dominant, e.g. a walled residential compound, towards its outside or vice versa).[112] The distribution (potentially combined with density) pattern of (clustered classes of) orientations could be visualised by locating them in the dataset.

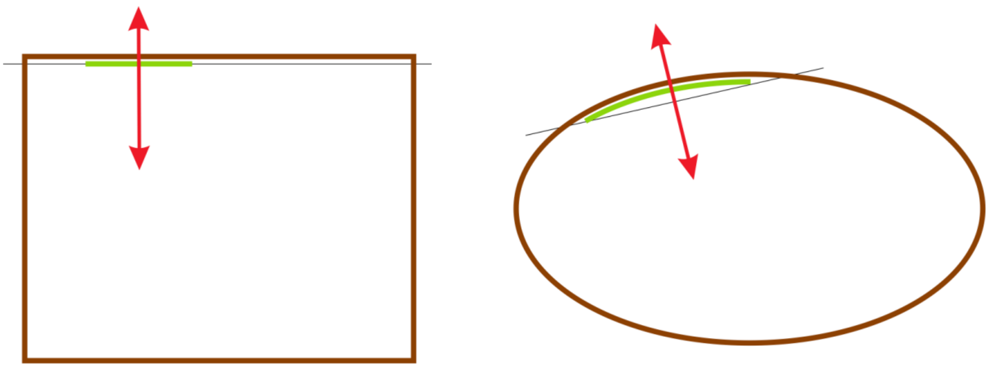

Fig. 8.5: Diagramme of the main principle of measuring orientation
This diagramme hypothesises the measuring of orientation of two Type 2s as part of Type 1s. The hairline indicated the direction of the boundary, with the red arrows indicating the orientation.

[112] Taking into account the unusual possibility of two adjacent dominant BLTs the size of the subdivision might be considered to reason out the mutual orientation.

Because multiple facing and extended facing boundaries can be identified per topological side, multiple orientations are the logical consequence. Therefore the analysis of orientation should include the differences in degrees that may occur within a single dominant boundary and configurative complex. Then the distinction between either single or multiple orientations in dominants only or in dominant configurative complexes can be made, which could in turn be connected to the context of topological segments (and configurative complex composition) in which they occur.

Building on the qualitative distinction in BLTs between facing and extended facing boundaries, the orientational relationship between them can be analysed. Rather than uncritically relating all extended facing boundaries in a configurative complex to one or all facing boundaries in a dominant, either the causal relation between any facing and the effectuated extended facing boundary or the extended facing boundaries on each topological side can be used. Measuring in this way distinguishes between mutual interactional orientations from the inside and from the outside respectively. Comparing the related orientations[113] may indicate several things of interest.

First, the orientation between dominant and surroundings is stronger from the inside if the facing and extended facing(s) roughly share their orientation. Second, the mutual orientation is unambiguously diversified by a facing boundary related to multiple extended facing boundaries on a single topological side and ambiguously diverse with orientations on multiple topological sides. Third, the mutual orientation is mitigated or obstructed by strong mismatches between the orientations of causally related facing and extended facing boundaries (e.g. a house entrance not aligned with the street line).[114] This last possibility could be further investigated by measuring if the other topological segments on the topological sides of the involved associated boundary do share the facing boundary's orientation (e.g. a plot to the side). When the orientation is predominantly not shared, but a materially emphasised associated boundaries are mitigated by extended facing boundaries that are not aligned (e.g. gates in unaligned garden walls) the break in the mutual orientation is emphasised. The orientation(s) of a configurative complex is/are decided by the extended facing boundaries, which could be ambiguous if different on one topological side. In all cases the frequency of particular

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[113] There is obvious potential to combine orientations with more architecturally detailed conceptualisations, e.g. on the front or facade of buildings and plots.

[114] Note that these ways of looking at orientation bear some resemblance to the space syntactic idea of constitutedness (see Chapter 6; Van Nes & Lopez 2007; Palaiologou & Vaughan 2012; Van Nes in prep.).

orientations of the same complex could be used to qualify the connectedness to a particular internal or outside relationship.

In order to get a better grip on the orientation from the outside, however, the orientation of the fully shaped subdivision should be related to the orientation of the entrances involved. A separate piece of software (*Morphal*) has been developed in recent years to measure plot-based (in roughly rectangular geometries) morphology, including compositeness and orientation (Grosso 2011). Additional development would be necessary to enable such urban morphological measures in more irregular morphologies. It should be stressed there is no theoretical interpretive support for the socio-spatial significance of the exactitude of the measurement in degrees of an orientation,[115] but orientation is rather theoretically supported in the relational way they qualify and articulate the connection between subdivisions and aggregates.

Paths and crossings

The locational context also manifests itself in the way that any location within a system is connected to other locations. Therefore, it includes the socio-spatially accommodated means to reach (and use) natural and social resources residing in the urban built environment (i.e. access routes to any activity or facility). While the metric distance of any path traversing the built environment complex could be measured and, together with e.g. the topography of the local geography, can make a basis for mobility cost analyses and speed of travel to assess relative closeness (see e.g. Richards-Rissetto 2012; Richards-Rissetto & Landau 2013), here the emphasis is on the qualitative socio-spatial differentiation of movement.[116] In boundary terms, associated with metric distance, each path or route is characterised by boundary crossings and after each boundary crossing one finds oneself in a location (subdivision) that is composed of new socio-spatially restricted and enabled interaction opportunities. This essentially constitutes a relative distance between origins and destinations within an urban built environment. Careful and preliminary examples of traversability and an origin-

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[115] See Chapter 1 for a discussion on the disparate *high-level* meanings where orientation is tied to socio-culturally specific (religious, cosmological, ideological, etc.) ideas and symbolism. This analysis, however, could still be used in support of those conceptually different approaches and aims, as suggested in introducing this section.

[116] It should be noted that this relates to space syntactic accessibility analysis, though based on disparate theory and analytical units and therefore eventually captured by markedly different measures and interpretations. For a brief discussion of space syntax applications see Chapter 6.

destination path (the socio-spatial effects of going from A to B) are given in **Chapter 9**, while more generic characteristics will feasibly require a computational tool.

The idea to index or analyse for each occupiable subdivision or location (as resulting from initially an entire single BLT identification) which topological segments and connections it is composed of, is a functional hypothesis already hinted at in the section on the dimensional context for analysing topological segment lengths. Here this can be repeated for the locational context and in particular the way interaction opportunities anywhere are restricted and enabled. This could result from an overview of the number, diversity, and order (connections) of topological segments per location, here seen as boundary crossings. In this way hypotheses could be addressed, such as the expectation that streets (collectively) direct one to the greatest diversity of interaction opportunities (as qualified by topological segments).

The diversity of boundary crossings for each location can be presented relative to the total unique topological segments occurring in each case study. This proportional correction reveals how diverse the conglomeration of topological segments forming any subdivision is, relative to the diversity of the urban built environment complex as a whole. In comparative perspective this measure would make such selections of relative locational diversity insightful between either all subdivisions taken together or per BLT. The order of topological connections of a subdivision can be analysed in terms of the homogeneous and heterogeneous construction of how that location is connected to other locations and how many changes in interaction opportunities that represents. When the results of analysing the socio-spatial composition of subdivisions are plotted geographically the morphological situation in which they occur can also be taken into account.

Envisioning a path through the occupiable spaces of a built environment complex as traversing beads on a string, it is clear that between any origin and destination a number of boundary crossings is expected. Furthermore, with each crossing a particularly characterised socio-spatial situation with associated opportunities is encountered. Taken together the amalgamation of all these socio-spatial qualifications provides the full socio-spatial redescription or ontology of an origin-destination path.

In principle each topological segment could be seen as the site for a boundary crossing, even if it involves the material property of impermeability. As defined in **Chapter 5** the axiom of BLTs is that they can be traversed except for the ones that are materially impermeable and therefore closable or (negative) boundaries of unoccupiability. So, explorations of the socio-spatial route characterisations could easily be amended to exclude the possibility of crossing boundaries that are materially impermeable in general and/or avoid the dominants and boundaries of inoccupiability. Such constraints could be designed to follow the logic that crossings are inhibited if transformative and/or unsolicited acts (see **Chapter 5** on soliciting interaction with dominants) would be necessary to cross. That is, disruption of the material properties and secluding (closed-off) social properties of the configuration should be avoided in passing. In addition, it is not a given that when a boundary is crossed there is always *direct* social interaction at play. That will only happen when the residing socio-spatial system is being performed at the moment of crossing, while the self-referential understanding of the crossing as a materialised socio-spatial interface itself is not lost when this is not the case (cf. **Chapter 3**).

Furthermore, in **Chapter 7** it was stipulated as an important premise for interpretive work on built environment data that all occupiable spaces must be reachable from eventually openly accessible locations. After all this is a bare necessity for fulfilling the requirements for the functioning and coherence of the residing society and the survival of its individual members, who require access to resources either directly or through social contacts, exchange, and services. Within an inhabited urban built environment the accessibility of resources for subsistence and maintenance has become intertwined with the arbitrariness of social structuring, mutually constituted by (encounters with) the material presence of the built spatial configuration. From this it logically follows that the number of potential routes accommodated in an urban built environment is almost infinite. Yet, it is stressed once more that BLT mapping does not support probability measures of the movement that will occur in the space syntactic sense (cf. **Chapter 6**). As a consequence, the analysis of routes or paths and boundary crossings would be largely unintelligible as a measure comprising an entire dataset.

Instead, paths and crossings should probably be directed by *a priori* human selection in support of existing hypotheses aiming for more profound understanding or new hypothesis building on an urban scale, while it could always be used to assess hypothetical individual paths (cf. **Chapter 3**; time-geographical life-paths, time-space resources, and the micro-geographies of everyday life, especially Pred 1977, 1984, 1986; example in **Chapter 9**). Using topological segments there is an opportunity to generalise path analysis computationally if the relative distance between specified topological segments is of interest. An analytical tool could enable one to reveal, with or without particular crossing constraints, the metrically most direct path, respecting the polygonal borders of subdivisions, between either a specified topological segment to a particular kind of topological segment or between any pairing of predetermined topological segments and return the number[117] and kinds of boundary crossings for these paths. While for a specified topological segment (i.e. selected as the leaving point for a particular location[118]) this could help hypothesis building, at this time the generic alternative seems complicated beyond inhabitants' comprehension. The outcomes of such generic analyses of boundary crossings then would comment on the relative socio-spatial coherence between all locations in space, which more readily pertains to the aggregative context.

Probably more productively, there are a multitude of possibilities to combine path and crossing analyses with additional data on actually navigated paths[119], land-use, activity areas, production sites, and other (economic, social, political, and cultural) functions, which will no doubt form an interesting future direction of research as subsistence and economical strategies can then be tied to socio-spatial patterns. Diachronically speaking, adding data on the labour investment in creating and maintaining built subdivisions and the obliteration of materially impermeable boundaries (i.e. enabling the actual crossing or transformation by penetration of such sites, e.g. the Berlin wall) forms another way to investigate the connection to resource use and access in relation to boundaries.

Again, all measures suggested by the locational context are open to additional analysis through time. This would seek to compare and determine the processes in which e.g. impermeable material properties, mediation of dominants, configurative complexes, socio-spatial paths, subdivisional composition, and other qualifying properties, such as orientation, persist or change within urban development.

Proposing analytical measures: aggregative context

As described in **Chapter 5** the aggregative context captures the way that coherent (whether consistently homogeneous or heterogeneous) patterns emerge or are imposed

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[117] Again a comparison with space syntax is possible, this time with global integration values and topological depth (see Hillier & Hanson 1984; Van Nes in prep.). The number of boundary crossings along a path is also a form of topological depth.

[118] In analysis this would start from a particular boundary crossing rather than the locations this considers. This is an analytical construct as boundaries are actually fiat sites of difference (see Chapter 4) which cannot be occupied themselves.

[119] Integration with space syntax's probability of viable routes could result in better understanding as well as more elaborate hypotheses. Especially in more contemporary settings one might want to differentiate modes of transport also, making the state of technology of importance diachronically.

from ideas and emplaced lived experience the inhabitants adhere to. The aggregative context at once holds the most simplifying power of all analyses as it can amalgamate on and address the large scale within a case study in a way the dimensional context and the locational context cannot. At the same time it concerns the most intangible of ideas and interpretations, as the emergence of entities can occur in almost every way and shape depending on each individual person. Aggregating boundary complexes are understood as contingent outcomes of the full breadth of interaction processes of inhabitation and can attain any scale (cf. Marston 2000). Since the aggregative context as a level of socio-spatial significance was necessarily preceded by an understanding of constitutive processes (**Chapter 3** and **5**), which has been structurally invested in GIS data, analysis with regards to the aggregative context can contribute to what Marston (2000: 221) sets as a goal for geographers: “to understand how particular scales become constituted and transformed in response to social-spatial dynamics.”

Where aggregates emerge, it could be said that there is some interest from the dimensional context again, as the size of aggregates should relate to overarching socio-spatial systems appropriating and manifesting a materially constructed signature within the urban built environment. In the sense that boundaries form entities, the entity of the subdivision is already an aggregate, and furthermore the dominant configurative complex represents an aggregate. These are both aggregates in a restrictive sense and therefore part of the analytical measures discussed above. With the aggregative context we move into considerations of neighbourhood effects, districts, and (social, functional, morphological, etc.) zones.

In reality many opportunities for aggregative analytical measures fully depend on the aforementioned measures and this has been indicated at various points. It is a more radical freedom of overlooking the entire composite complex in which the analytical measures of the aggregative context still may differ slightly. At various scales then, experimentally detecting emergent entities can diminish the complexity of the overview of an urban built environment complex redescribed as a BLT map.[120] Furthermore, aggregates can have their own temporal dynamics and development patterns. When trying to identify aggregates it is paramount to keep in mind whether the aggregate as a whole makes sense interpretively. If there is no sensible interpretation for the pattern, chances are they represent an example of a statistical artefact (cf. Franz & Wiener

[120] Here a connection to urban morphological plan units and regions can be made (see Chapter 6).

2008). All entities, including aggregates, form internally coherent and contextually dependent seclusions.

The scale, arbitrary diversity, and associated complexity of aggregates implies that without experimenting with computational aids, the intuition and awareness of the researcher is key (cf. urban morphology, see **Chapter 6**) for such analyses. Chances are the complexity of the socio-spatial differentiations contained in any aggregate would often be too large to coherently reason with. **Chapter 9**'s diachronic example shows a minor way in which small-scale predetermined aggregates could still be used on the basis of extracting information from reading BLT maps and a human understanding of the represented topography.

Adherence to patterns

The patterns emerging or imposed from the ideas and emplaced lived experience inhabitants adhere to usually would refer to larger-scale processes inhabitants feel they are part of. This could include the overarching ideas about participation, belonging, and connectedness to something, which would have been conceptualised and/or learned (see **Chapter 3**). At the same time, functioning in an urban built environment complex also represents often unconsciously participating in socio-spatial systems on a grander scale, which mediate between and connect the socio-spatial systems in which we are aware of our participation. For example, we unconsciously make use of transport routes to connect from home to the market. Both of these are aspects of adherence to a specific kind of coherence accommodated in the socio-spatial composition of the built environment configuration. Aggregates can be both thematically defined as a socio-spatial pattern on one particular scale, or indeed hierarchical, in which by and large minor emergent entities dissolve into larger ones.

The ideas and experiences of coherence we adhere to are protean and volatile.[121] Ideas are not fixed. Experiences change and nurture their development, and their translation into actions does not lead to perfect intentional outcomes. This means that although it is advantageous for simplified, deeper understandings to look for aggregate

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[121] On an everyday emergent scale it combines what I do and the frequency of that (role) with how far (socio-spatially relative distance) the socio-spatial systems I participate in are removed from areas familiar to me, whilst always exposing me to ideas to learn and possibly impose which are outside my own direct experience. I live in a neighbourhood, which is connected by a traffic artery that gets me to work, only part of which is in my neighbourhood. My neighbourhood is part of a district, which is part of a city. The city has limits but is also part of a conurbation, so what I know and experience are not the same, etc.

entities formed by coherence patterns, such a structure may occur in virtually infinite versions of order and shape. In most cases it should not even be expected that their edges are defined clearly and their edges could be extremely amorphous. All detected patterns might feature partial overlaps and coincidences, which would be best presented in gradually changing zonal distributions in plans (cf. the heat map). It is of interest to combine outputs of different aggregating analyses, as their edges could reinforce each other or show significant deviations demonstrating possible flexible and fuzzy interplays of socio-spatial factors. There is no *a priori* way of knowing all the different forms of coherence.

Uncovering consistency within a whole area can result from any of the topological and morphological measures discussed before. While quantitative analysis can help identify such patterns, the final judgment about coherence and when a lack of consistency constitutes a significant marked difference is still down to the human mind. Making such a decision is inherently subjective, even though it is guided by and confined to the theoretical framework.

Within the locational context of boundary crossings we find the most radically free and potentially different aggregating analytical measure. When analysis of boundary crossings is not route dependent it can reveal the versatility or homogeneity of potential interaction opportunities accommodated throughout the spatial configuration, which can be analysed in terms of the order in which the crossings occur, regardless of the likelihood of the route chosen. The aim is to uncover patterned clusters within the sequential distribution of boundary crossings. When this is done for the whole dataset it is not about how many boundaries are crossed, but in which order they come. However, a larger number of boundary crossings could reveal more complex rhythms in the string of steps. Nonetheless, this step focused approach seems interpretively shorthanded from the outside due to the randomness of the hypothetical path. A more fruitful technique could be to focus on choice.

Focusing on choice of boundary crossings across the entire complex, the number and the diversity of choices is analysed after each boundary crossing. All paths are tried (somewhat like a maze), with possible restrictions for impermeability, dominants, negatives, or the mitigating informal effects of virtuals, and logically terminating at solid dominants (crossing into Type 1s). Any pattern in the options one encounters (possibly also incorporating metric distance to the next crossing) amounts to potential interpretable consistency. At this time it is not clear what the best technology to implement such ‘all-to-all’ analysis is, but a possible way forward is by developing a *tree hierarchy* clustering tool, which recognises inherent limits to consistent patterns in choice options. Another way to inform this cluster analysis is by incorporating the order of the topological connections comprising how a location (or occupiable subdivision) is connected to other locations. Tied to the boundary crossing sequence and/or the geographical location, recurrent or persistent patterns in this topological composition could be identified. Whatever option of this large-scale analysis is selected, limiting the variety of BLTs or topological segments that are deemed significant can be expected to improve the clarity of results as the experimental combinatorics are reduced.

Since looking for aggregate entities necessarily covers the entirety of the data selection, in these analyses the relation to the world outside the data selection can be of importance. This is especially true for analysing patterns of boundary crossings as steps along routes. In such a generic analysis of paths to all locations (with or without selections and constraints), an informed starting point can still be chosen. Within the confines of the dataset this would be formed by topological segments involving a Type 1-2 (closing and facing boundary) combination, as places where one leaves from the most secluded to the rest of the system. Starting outside of the limits to the area covered by the dataset, this could be formed by topological segments involving open boundaries, especially Types 5, 6, and 9 (directing, disclosing, and opening boundaries), because they are particularly conducive to movement and when originating from outside, incoming movement is necessary.

Using informed starting points, an alternative approach could be to focus on the number of steps (cf. space syntactic topological depth). The first question could regard how many steps are needed simultaneously going from all starting points to cover the entire complex. In comparative perspective this could form a basic indicator for the socio-spatial differentiation one is likely to encounter traversing the urban built environment. Further, arbitrary numbers of steps could be used to on the one hand reveal which parts of the built environment can be reached in a number of steps, or how few or many steps are needed to reach a particular location. Again employing any number of possible constraints, both the order of the sequences and the depth could help place and cluster locations socio-spatially with respect to the starting point and within the entire built environment.

When clusters are identified and seem interpretable, the edges and fuzziness of the cluster in geographical space and in related to the BLT data need to be determined. Because the boundaries are merely sites of difference which do not occupy space, any pattern ‘ceases’ somewhere within a subdivision. This interpretive practice bears resemblance to morphological seams (see **Chapter 6**). The edges of zones can interpretively be associated with a contiguous line of topological segments. Through time this boundary line could persist with or without constancy in the topological segments, reinforcing the socio-spatial significance in different ways. The characteristics of zonal edges of any detected aggregates have elevated constitutive significance as they comprise aggregate sites of difference.

Although morphology is of relevance, the BLT data structure is not sensitive to and expressive of geometrical shapes. This naturally improves comparative applicability, but means that the theoretical framework lacks conceptual interpretive support for analysing particular shapes as a unit. Additional conceptualisation on this point would enrich the current approach, possibly in conjunction with architectural concepts enriching the basic material distinctions considered in this research. It is not implied that consistency and change in terms of the BLT data structure is replicated in architectural morphology, yet it is contended here that based in terms of the rudimentary socio-spatial significance to inhabitation within this research, the essence of such situations is retained regardless. It applies as well that any (aggregative) pattern detected within the current data structure that remains unintelligible, could become intelligible when integrating supplementary aspects of the urban fabric. When analysing one should at all times be aware of the interpretive limitations the scope of this research imposes.

If there is data available on the zonal divisions (including land-use) of a city, it seems advantageous to work with these in conjunction (cf. Stanley et al. in prep.), comparing the socio-cultural, political, administrative, economic, etc. knowledge with the entities emerging from pattern analyses. There is no need for any of such known zones to be reproduced from the BLT data, but differences and concurrences make possible vantage points for research questions and hypotheses. At the same time the socio-spatially emergent zonations, if interpretable, are always significant as they are likely to indicate practice based and possibly more subconscious structuring within an urban landscape, which still inadvertently would have had some causal effect on the concepts that are instated.

Again, all measures suggested by the aggregative context are open to additional analysis through time. This would seek to compare and determine the processes in which aggregates form, consolidate, change, and disappear or hierarchically dissolve within urban development.

Final remarks on analyses

Two last remarks regard first diachronic analysis and second accounting for interpretive flexibility in understanding BLT identifications. First, both the data issues and the opportunities for developing diachronic analyses on the basis of the proposed analytical measures have been discussed. The basic premise is to reveal the patterns or rhythms of development through time, that is the processes of urban development particular to each case, and eventually to identify similarities and differences in those processes comparatively. The persistence and recurrence of socio-spatial characteristics indicate particular socio-spatial significance on that site of difference. One major difference is that the morphology of the boundary lines or boundary segments is part of the analysis. While a different BLT data structure through time constitutes change, the actual site of difference could itself have persisted through time along a certain length or intermittently. This means that both the developments reconstituting a persistent line and the BLT data structure very close to a preceding boundary line are of interest. The latter will help differentiate between modifying shifts (e.g. widening, straightening roads for cars[122]) and real transformations of the configuration. This reconfirms the importance of addressing the aforementioned computational difficulty with detecting morphological or geometrical change between time-slices. While the interpretive confines of this research will not permit explaining why a built environment develops through certain processes, the processes themselves can be understood in terms of the constitutive interaction opportunities each stage offers to its inhabitants.[123]

Secondly, in many cases there will have been a degree of ambiguity or flexibility in the interpretive practice of BLT mapping. Running any analytical tool therefore never produces an absolutely final outcome or insight. To account for known ambiguity in interpretations (e.g. knowing that covered markets would often be open like street

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[122] While minor and even major scale enlargement may not affect topological relations, the increase in surface volumes will decrease density, which is a qualifying variable to distance setting and encountering (changes in) interaction. Typically scale enlargement will not be able to fully maintain existing shapes, as often not everything can grow equally, potentially also leading to changes in (mutual) orientation.

[123] Weber (1979: 385) might have had something else in mind when he wrote: "A genuinely analytic study comparing the stages of development of the ancient polis with those of the medieval city would be welcome and productive. […] [The aim should be] to identify and define the individuality of each development, the characteristics which made the one conclude in a manner so different from that of the other. This done, one can then determine the causes which led to these differences," but his reasoning is both astute and appropriate, as determining the causes of what occurred in terms of built form depends on supplementary lines of evidence and enquiry.

spaces for most of the day), it could be of interest to render the analysis more than once[124] for these differing scenarios. Naturally, several of the most frequent uncertainties will have been captured in rules of thumb (see **Chapter 7**). Critical research practice would include the marking up of particular varieties of flexibility and ambiguity so the respective data entries can be retrieved later. In the same way, the conjectures in historically reconstructed and archaeologically derived outline base plans could be critically reassessed when deemed necessary.

On the basis of the analytical proposals and developments in this chapter, the final chapter will be dedicated to carrying out some preliminary explorations on the basis of the redescriptive and analytical opportunities currently available to us. The full breadth and scope of computational developments and experiments that have been informed and form hypothetical technical possibilities is not part of this research, therefore only initial indications of the interpretive potential can be demonstrated. The aim is merely to establish a basis for what might work for full-fledged case studies and to evaluate the opportunities offered by translating the conceptualisations into a spatial data structure in GIS. By working with GIS as an exploratory, visually redescriptive, and inferentially invested tool and structure, it is hoped that for both social scientists and humanities scholars the 'black box' effect (cf. Griffiths 2013; Lilley 2012) is abated.

[124] In space syntactic studies the benefits of running analyses on several data scenarios has also been noted (Hillier & Hanson 1984; Van Nes in prep.).

CHAPTER 9 – PRELIMINARY EXPLORATIONS AND VISUALISATIONS OF SOCIO-SPATIAL SIGNIFICANCE IN CHUNCHUCMIL'S AND WINCHESTER'S URBAN BUILT ENVIRONMENTS

Introduction

The BLT data structure and the analytical measures, which have been devised in **Chapter 8** according to the levels of socio-spatial significance which also simultaneously guide and inform inference from conducted analyses, have opened up a wide array of experimental investigative opportunities. From the outset, and especially **Chapter 7**, it has been stressed and explained that the main objective of this research is to develop a methodological approach. This imposes limitations on the space available to design and construe full-fledged case studies, including recapitulating the disposable information on their contexts. Instead, due to a focus on demonstrating the research processes involved, a strictly limited test case approach was chosen. Yet, care has been taken to ensure that the current data work offers a sound foundation for future research. Such future work may entail the pursuit of purposively predetermined socio-cultural detail. While deliberately not intrinsically comprised in this method, it should still support such aspects of spatial independence (**Chapter 2**) as an undercurrent. This chapter therefore has a significant final step to make, which entails the demonstration of preliminary explorations and visualisations on the basis of the test cases.

Due to the experimental character of the analytical work enabled by employing BLT mapping on urban built environment data, what is presented in this chapter is necessarily bound by what could be made possible technologically (geocomputationally) most readily (cf. **Chapter 8**). The interpretive exploratory examples in this chapter therefore serve the purpose of showing the possibilities I take to be enabled using the BLT data structure and the information they contain. While the confines of the current project only allowed for a sample of these exploitative possibilities, it is envisaged that future research efforts can freely develop further and new opportunities on the basis of what is presented here. After a presentation of some general statistics computed on the ontologies of Winchester's MM and Chunchucmil, data for the latter will primarily be used for detailed descriptive explorations and interpretations. This exploits the characteristics of its spatial-material urban pattern. This pattern is considered to be radically different to what most urban research is focused on, and recent advances in Maya studies are only beginning to assess geographical analytical opportunities. In this way the socio-spatially alternative and comparatively improved viewpoints enabled by BLT mapping will be emphasised. It should be acknowledged that this cannot be comprehensive and therefore, to complement the extant architectural focus in Maya research (see **Chapter 7**), this exploration will concentrate on the relation between the spaces affording ‘open circulation’ and spaces associated with architectural groups. The historical Winchester data will primarily be used to perform an initial demonstration of opportunities offered by diachronic analysis. Some incidental and explanatory contrasts will be sketched out.

Geocomputational statistics on the ontology intrinsic to the city

Chapter 8 introduced the idea that topological segments, as the smallest meaningful elements, compose the ontology intrinsic to each city, or the socio-spatial signature. This notion was proposed in **Chapter 5**’s discussion on interpretation on the basis of the BLT ontology, which developed the levels of socio-spatial significance. Since the BLT ontology is a conceptual ontology of types and therefore ontologically partial, only through the interrelated way in which the BLTs occur in a city would a full ontology, which is particular to each city, be unveiled. The geocomputational tool sourced as part of this research, able to detect the topological segments, initially provides a revealing insight into the characteristics in the dataset. Because the datasets currently available are restricted to the test cases, their interpretive potential is limited. After all, the extent of the test cases is informed by a practical and methodological rationale (**Chapter 7**) and therefore, as a unit, they do not represent a section of spatial data we know to be socially significant. The way the statistical output of the tool should be treated is therefore as if the extent of the test case data would represent a whole city.

The statistics represented here consider the test case area of Chunchucmil and an extended area prepared on the basis of MM for Winchester. These two areas are topographically comparable in the sense that they both take a section of each city bordering the monumental or administrative core (these terms are indicative rather than accurate) and then stretching outwards. That concerns for Winchester the eastern side of the city centre (formerly intramural) stretching east across the river, and for

Chunchucmil the northwestern edge of the centre containing the largest monuments continued in the northwest direction. Otherwise any comparison between the two should be seen in terms of a first contrasting of an example of a high-density and an example of a low-density urban tradition, of which the historical period is an arbitrary aspect.

First, the tool[125] allows us to inspect how many differences in topological segments occur in the composition of each city's ontology (cf. **Note 110**). Not counting the additional specification of virtuality (i.e. virtual boundaries involved in the combinations creating topological segments), but separating out the Type 5s that through virtuality allow for choices in the direction of traversing (i.e. the number of options at intersections), Chunchucmil contains 70 and Winchester 43 differences in topological segments. At first glance this is suggestive of considerably less complexity in Winchester than in Chunchucmil. However, the tool also shows that the Winchester test case does not contain examples of Types 6 and 7 identifications, which could have increased the complexity in Chunchucmil far beyond the 70 topological segments currently detected. The test cases have 38 topological segments in common, meaning that Winchester has only five combinations unique to its situation, while Chunchucmil has 32.

The tool also provides us with the basic absolute measurements on the test cases, which allow us to derive further statistics on the topological segments. **Table 9.1** contains the total count of topological segments, the total length of the combined boundary topology (the selection of the outline base plan used in successful BLT identifications), and the total rectangular area[126] of each test case, after corrections for errors as identified in **Note 125**. The proportion of virtual boundaries in Chunchucmil accounts for 11.4% of the count and 7.34% of the length. This is 2.84% and 4.92% in

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[125] The readings of the geocomputational tool developed for this project show certain discrepancies with the topological segments that would intellectually be expected, which causes minor differences in the statistical values. Although every attempt has been made to minimise data errors these cannot be excluded (see e.g. Chapter 7 on topology checks, while some interpretive ambiguity was intentionally allowed during the BLT identification process). The software interacts with native ArcGIS binaries, and debugging the native algorithms is beyond the remit of this thesis. In the following statistics I have filtered out erroneous results manually, which is possible because the combination of BLTs in the topological segment should not contradict itself and fulfil the ontological requirements stipulated in Chapter 5. Nevertheless, the errors are within acceptable limits, accounting for 1.3% of the total count and 1.0% of the total topology length in Winchester, and 1.5% and 1.3% respectively in Chunchucmil. The interpretive ambiguity accounted for 0.3% (count) and 0.2% (length) in Winchester, and in Chunchucmil respectively 0.2% and 2.4%.

[126] The native binaries of ArcGIS responded inconsistently to attempts at incorporating the somewhat more precise (i.e. more tight circumscription) convex hull as a measure for the area. A convex hull virtually creates a minimal convex polygon which includes all data.

Winchester. It is likely that archaeological preservation in Chunchucmil is partly responsible for the higher virtual boundary stakes, but it can further be expected that in Winchester there is a social need to materially mark all distinctions completely, rather than circumstantially.

Test case	Total count (n)	Total topology (m)	Total area (m^2)
Chunchucmil	5202	62370.62	886817.12
Winchester	5178	34229.23	324875.24

Table 9.1: Absolute measures of the topological segment ontology for the test cases

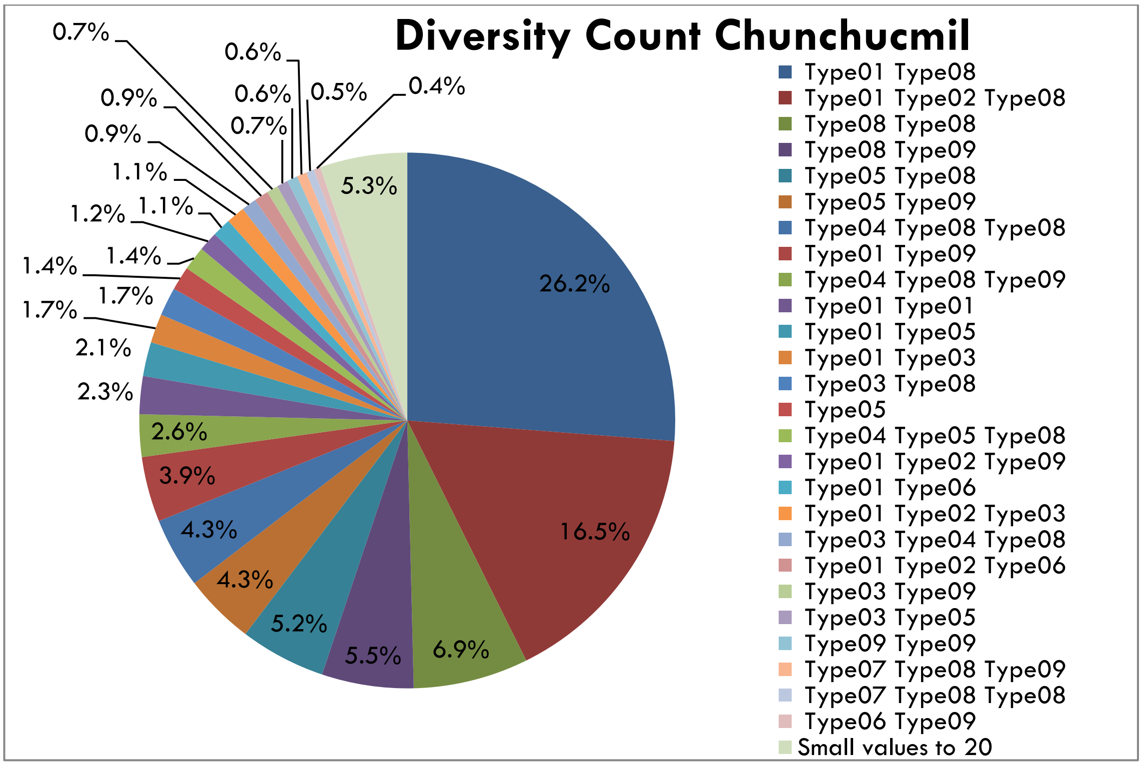

Fig. 9.1: Chunchucmil's proportional diversity count of topological segments

The measures used in **Table 9.1** allow the calculation of the proportion in which each topological segment occurs (its relative count) and the proportion of the length of the boundary topology it partakes in. In addition, the number of centimetres of topological segment can be expected to occur per metre squared (a measure of density, see **Chapter 8**). **Figs. 9.1** and **9.2** present the pie charts of the relative counts of topological segments for Chunchucmil and Winchester. Due to the large number of socio-spatial differences they represent, these have been simplified at the bottom end. This means that the lowest values have been lumped together. When a topological segment occurs up to 19 times within the subset, it is included in the small values class. By doing this it transpires that the most infrequent socio-spatial differences are responsible for the greater diversity within Chunchucmil's topology. Without these infrequently occurring topological segments both cities retain 26 more frequent socio-spatial distinctions. While this may be an inadvertent figment of the test case area selections, if these areas are roughly representative it suggests that in Chunchucmil a larger number of specific socio-spatial activities or situations are positioned in materially marked connection to regular materialised socio-spatial differences. This could be indicative of distinct architectural compositions accommodating a specific activity or status, requiring this variety of specialised material patterns. Such arguments could be further developed with a larger coverage e.g. including the monumental core where specialised and unique patterns would logically be expected. Another argument could be that Winchester accommodates a more equal and constant pattern, suggestive of higher demand for developing a similar social functioning across space (e.g. residential, commercial or mobile).

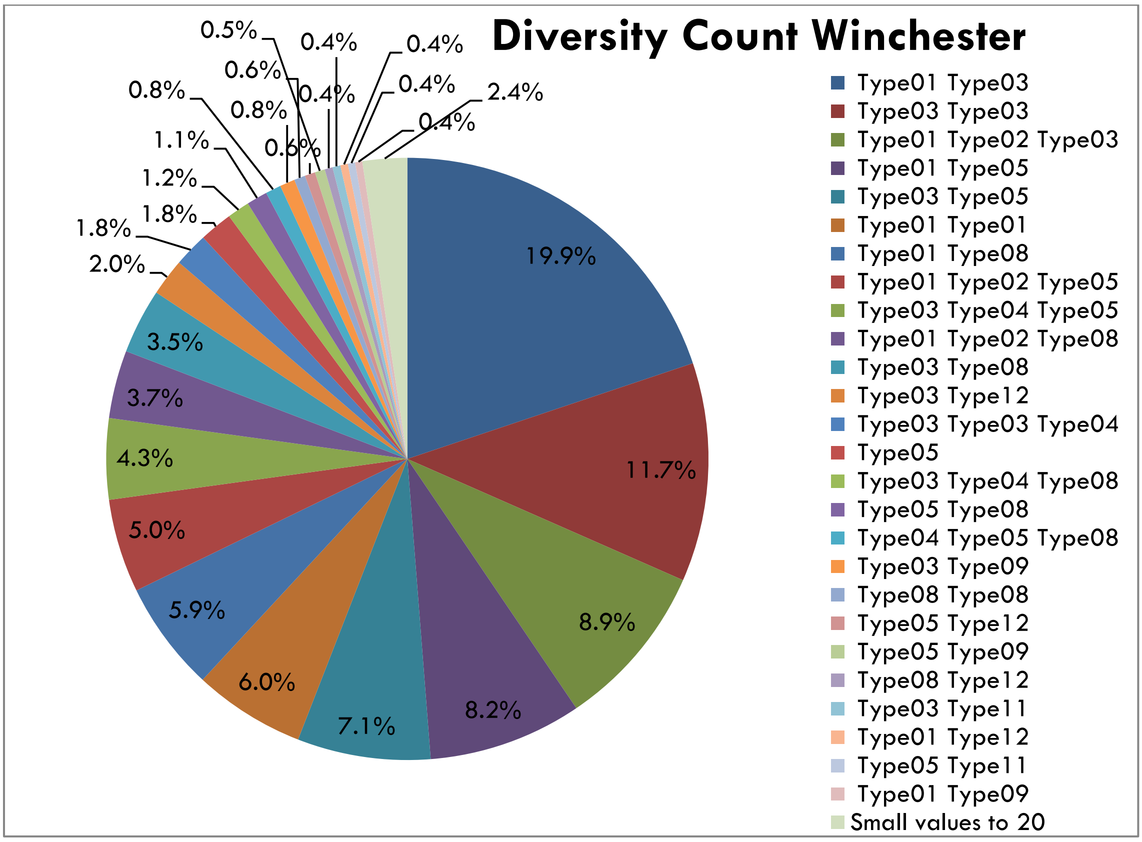

Fig. 9.2: Winchester's (MM) proportional diversity count of topological segments

Focusing on the proportional length, perhaps unsurprisingly we see a very similar division, with important constitutive roles of the same topological segments (**Figs. 9.3** and **9.4**). Two things stand out. First, in Chunchucmil there is a strong drop after the stake of the top two topological segments (Type 1-8 and Type 1-2-8), which basically indicates that a large number of smaller sections of boundary involving impermeable architecture (buildings) forms a greater socio-spatial constant, than the diversity along the longer, but less frequent Types 8 and 9 operations. Second, in Winchester there are four strong contrasts in the top determinant topological segments. These are firmly placed amongst the ten most frequent topological segments, while they take a sharp drop in terms of length. These all involve Type 2 or 4 operations (facing and extended facing) and are thus revealed as entrances. As explained in **Chapter 7**, precise knowledge on entrances is scarce for Chunchucmil's archaeology, and therefore longer indicative boundaries have been identified.

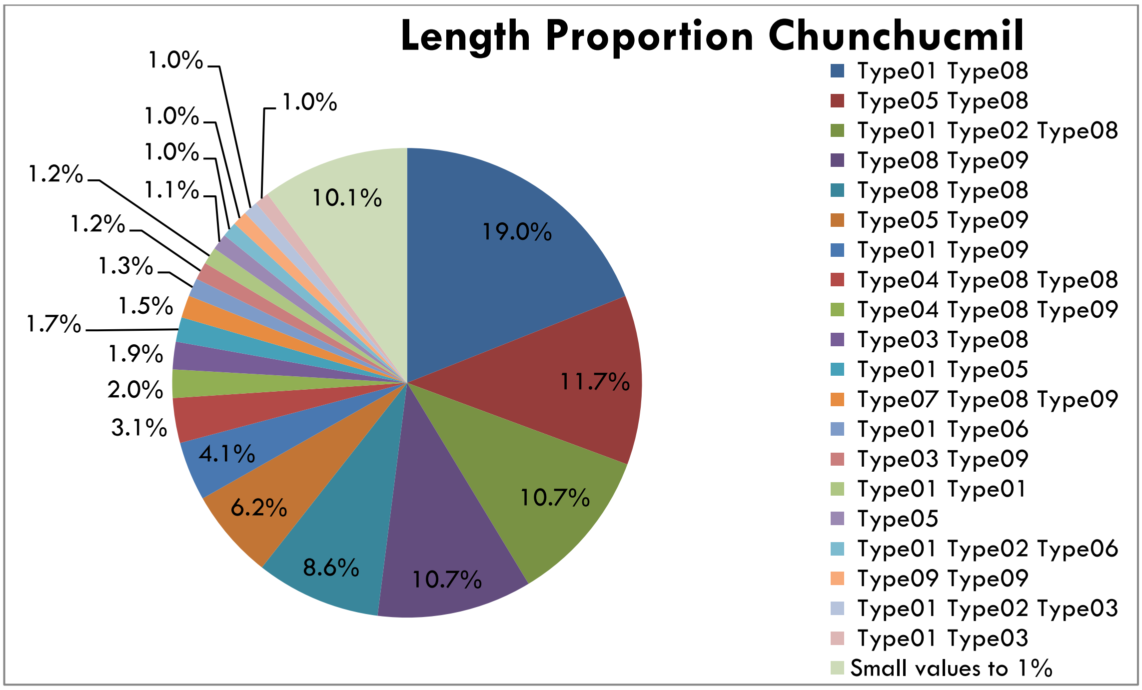

Fig. 9.3: Chunchucmil's lengths of topological segments as proportion of total

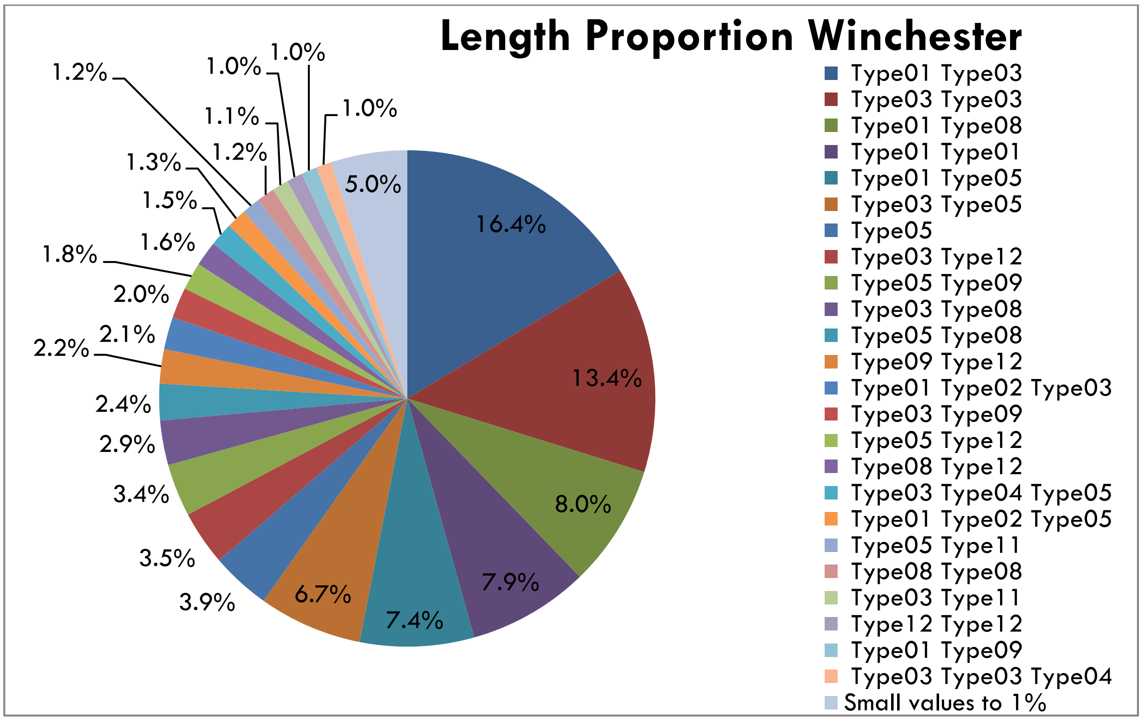

Fig. 9.4: Winchester's lengths of topological segments as proportion of total

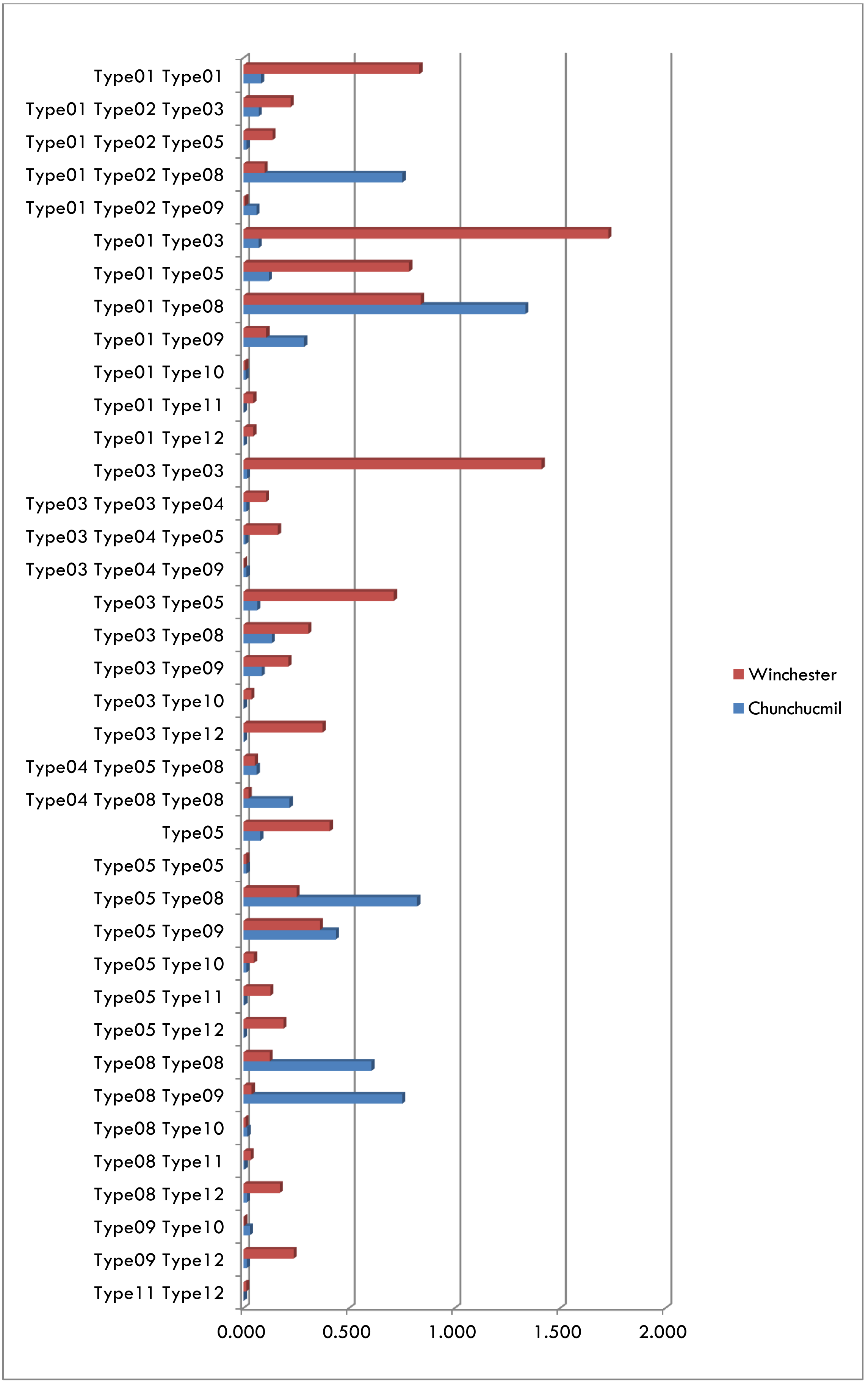

Fig. 9.5: Comparative length density (cm per m^2) for Winchester and Chunchucmil

Ending this whistle-stop tour of the general statistics, an example of the comparative opportunities this opens is given. In keeping with the contrasting terminology of high- and low-density urbanism (e.g. Fletcher 2009, 2012), **Fig. 9.5** presents a graph of the length density (a geographically absolute measure of cm per m^2) of the topological segments shared between Chunchucmil and Winchester. With an average density of socio-spatial boundary distinctions that is 2.5 times higher in Winchester (0.25cm) than in Chunchucmil (0.1cm), it is hardly surprising that the strongest contrasts show higher values for Winchester, although several topological segments involving a Type 8 operation form an exception to such expectation. As a crude quantification, however, it would appear that in high-density urbanism there are 2.5 times more opportunities to change one's socio-spatial position across geographical space, which in one way offsets the greater diversity in Chunchucmil as one is likely to have to travel considerably longer in order to encounter the opportunities this diversity offers.

It is clear that these general statistics could direct questions for further, more detailed investigation. While an attempt was made developing the detection of the BLT combinations at the connections (nodes) of topological segments, the functioning of this functionality proved unstable. The lack of insight in the contextual composition within which the current detections occur, as well as the inability to visualise the distribution pattern of occurrence and make geographical selections, strongly limits the interpretive argumentation that can be based on the statistical overviews. The following paragraphs go some way to introduce first a visualisation technique permitting the reading of BLT patterns as a map and the extraction of detailed contextual descriptions with the help of especially devised diagrams.

Exploring Chunchucmil's BLT data

Spatial analysis is not entirely new to Maya intra-settlement or intra-urban research.[127] Nonetheless, few urban surveys yet exist as GIS data (notable exceptions besides Chunchucmil are Mayapan (see Russell 2008; Hare & Masson 2012), Palenque (see Banhart 2003, 2005), Coba (see Folan et al. 2009) and Copan (see Richards-Rissetto 2012)) so examples of generic spatial analytical functionalities in GIS software are still scarce, but growing. Following up on an established practice of calculating the

[127] Spatial technology is more often used of site distribution patterns, e.g. *The Electronic Atlas of Ancient Maya Sites* (Witschey & Brown 2010).

overall density of the number of archaeological instances of architectural remains over a surveyed surface area (Rice & Culbert 1990), currently GIS functionality is used for density measures. This use typically focuses on a nearest neighbour density clustering approach (e.g. Folan et al. 2009; Hare & Masson 2012), and helps generate a general feel for the dispersion pattern of administrative nodes and occurrences of the elite classes throughout a site. It tentatively helps identifying possible residential zones and neighbourhoods (Hare & Masson 2012). Recently, a nearest neighbour clustering approach was used in conjunction with dispersion to explore patterns in grid alignment and orientations amongst architectural groups, but this approach was point (polygon centroid) based and did not perform the extensive data preparation conducted for BLT mapping (Bevan et al. 2013). An early GIS, not fully converted and functional (Hutson *pers. comm.* 2013), has also been used on Chunchucmil, aiding interpretation especially by using surface area calculation of residential groups' plots, which are tied to some observations on the material situation affecting urban life (Magnoni et al. 2012).

Furthermore there is some interest in assessing the spatial patterns of Maya cities in terms of political or administrative zones or catchments (Adánez Pavón et al. 2009; Bazy 2011). Adánez Pavón et al. (2009) hierarchically tie their interpretation of political units in Tikal to different types of plaza plans (Becker 2004), therefore creating a somewhat more formal architectural spatial version of the ethnohistorical approach to linking settlement layout to socio-political organisation seen in Carmack (1981) and Hill & Monaghan (1987). Bazy (2011) uses generalising observations on the private space of buildings and public space of plazas for schematic socio-political interpretations of the layout of Piedras Negras. Bazy takes into account the material properties of architecture affecting privacy and intervisibility to distinguish public from private spaces, but the approach is mainly operationalised for revealing the dynamics of the development of connected complexes through time. The material-spatial characteristics of the social functioning and dynamics on an urban level remain out of reach. Lemonnier (2012), also using a schematic interpretive rather than formal spatial approach, demonstrates a more intricate consideration of spatial relation between architectural group types, taking into account further topographical and geographical feature detail, arguing for probable socially connected units. Finally, a topographical GIS approach is further developed by Richards-Rissetto (2012) and Richards-Rissetto & Landau (2013) where built and natural features together shape the urban landscape conditioning the relative cost (least-cost analysis) of traversing the city. Measuring the likelihood of *through* and *to* movements, arguments are made for social integration and inequality patterns.

What can be seen in the current development of spatial approaches to Maya cities is the influence of the availability of better data and GIS literacy. Together with more intricate conceptual ideas on the shape and materiality of (urban) architectural features, these are leading to the development of a greater diversity of analytical methods. At the same time, most of the examples cited still depend predominantly on artefactual, stylistic, and ethnohistorical information to guide interpretation. The intricacies of the role of built space in constitutive social functioning on an urban scale require a more rigorous and comprehensive treatment of the fragmentary archaeological record and more formal morphologically and topologically conceived data to eventually consider urban space integrally with the aid of GIS' spatial technology. While the number of analytical measures that are fully operational and the degree of automation on the basis of BLT mapping is very limited, the following will demonstrate the stepping stones of the interpretive reach that is enabled on the basis of appropriately theorised, prepared, and formally redescribed material-spatial data as developed in this project.

Reading the BLT map

Since the hypothetical opportunities for advanced spatial analysis beyond general statistics (especially applied to patterns or selections as described in **Chapter 8**) largely remain a future prospect, some of the principles can be explored by using the data structure and properties as produced by BLT mapping according to simple visual inspection. While the inevitable limitations to work with the GIS data manually somewhat restrict the representative validity of analysis and interpretation, current findings can still reveal a number of directions in which research could be continued. In order to extract, represent and study the BLT data, the BLT map needs to be readable, which as shown in **Fig. 7.9** and discussed in **Chapter 8** is problematic as the polyline character of the data necessary obscures co-located lines, which in turn are inevitable at all times as each boundary line is identified as a BLT at least twice (see **Chapter 5**).

As described in **Chapter 8**, the hypothesised complexity of a visualisation tool which automatically rescales features taking into account their morphology was beyond this project, if developing this is indeed possible. However, a more direct alternative was found in developing a tool able to displace each BLT layer according to a predetermined offset along the X and Y axes. All this does is to shift the placement of each layer with respect to the one overlaying it by the number of centimetres requested, while retaining the top layer in its original position. In order to retain a readable map, meaning that the shape of the mapped features and their originally co-located relation are still recognisable, displacement should be kept at a minimum. It was found that usually 10cm suffices. Since across all thirteen layers containing the BLTs this still amounts to a maximum displacement of 120cm (130cm incl. the virtual boundaries), considerable distortion is caused. Therefore it is advisable to combine several standard ArcGIS visualisation options with the displacement visualisation tool.

An effective set-up is to remove virtual boundaries, Type 2s, and any layer not containing any data from the selection to be displaced, so no unnecessary displacement is caused. Following **Chapter 5**'s ontological primacy of seclusion, Type 1 is best kept in the top position. Otherwise the following order was used, mainly based on the expected frequency of relations between BLTs: 1; 3; 5; 4; 8; 9; 7; 11; 12; 10; 13. Type 10s are near the bottom because their 'neutral' or ambiguous definition usually extends pre-existing relations between other BLT identifications. Type 13 is closing (though not present in the test cases), because it would most often form the border of the data selection. Type 7 is placed below Types 8 and 9, because it can contain complexes of all BLTs and its superseding relation is expected to remain recognisable even with a larger displacement. After performing the displacement, the Type 1 based figure-ground polygons (**Fig. 7.10**) can be loaded in for clarity. Underlaying the displaced (in the terminology of the geocomputational tool: exploded) layers, the Type 2 and virtual layer can be reintroduced. Virtual boundaries would logically not concur with Type 1s considering the material evidence needed to identify Type 1s and therefore they fill unoccupied 'gaps' resulting from the displacement. The Type 2s would mostly co-locate Type 1s (next to some Type 7s if present). In their underlying position increasing the thickness of the way the polylines are displayed, would make them bleed out from underneath the Type 1s. An example of the end result of this visualisation shown in **Fig. 9.6**.[128]

[128] The main disadvantages of the displacement technique are the fact that co-located lines of the same type remain in their invisible overlaying positions and that depending on the shape of the features displacement in one direction along X and Y axes might follow the existing geometry and therefore virtually prevent underlaying lines to reveal themselves. In general a lot of panning and zooming actions are needed to properly see all the detail, while the jumble of actually absent intersections caused by the displacement can be confusing. Prior knowledge of the conceptual principles and technique is therefore needed to read these plans.

It is on the basis of this kind of visualisation that one can work to extract further information contained in the BLT data that can clarify relations and characteristics that an initial reading of the map may not immediately point out. The socio-spatial redescription represented by the BLT map in **Fig. 9.6** mainly reveals that the centrally placed large opening boundary does not directly relate to many closing boundaries (buildings) or boundaries directly associated with dominants, that it allows transition between several directing boundaries, and that relations to closing boundaries are mainly effectuated through crossing over disclosing boundaries first. Put in mundane terms, there is a large area that is bordered by many boundaries preventing one from accessing further specified interaction opportunities, while at the same time it is a flexible zone for people moving through either to engage in an interactional subsystem in which several buildings partake or move on in other directions.

Fig. 9.6: BLT data visualised as a BLT map revealing the different co-located BLT layers
(Image prepared upon original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

Strung beads on a string

The preceding socio-spatial description of the Type 9 in **Fig. 9.6** leaves many of the intricacies of the constitution of this space unmentioned, as it is difficult to extract the patterns and relations systematically from an irregularly formed and unfamiliar geometry. The initial subdivisions of occupiable surfaces (**Chapter 4**), socio-spatially reconceptualised by the BLT identifications, can be seen as a string of beads, assuming that one can traverse from one into the other. At the same time, the way these spaces are bounded is as a string of BLT combinations (the topological segments defined in **Chapter 8**). On this basis each BLT subdivision can be represented on an equal basis as an ideogramme, removing the irregularities, shape, and scale of the geographical situation to allow us to concentrate on the BLT information. To this end I have developed a polygonal clock diagram, in which each side represents a topological side. **Fig. 9.7** shows the clock diagram for the Type 9 in **Fig. 9.6** (from here: 9A). Importantly, the clock diagrams use the BLTs as primary analytical units as a heuristic device, rather than being based on the topological segments as analytically derived ‘smallest meaningful elements’ (**Chapter 8**).

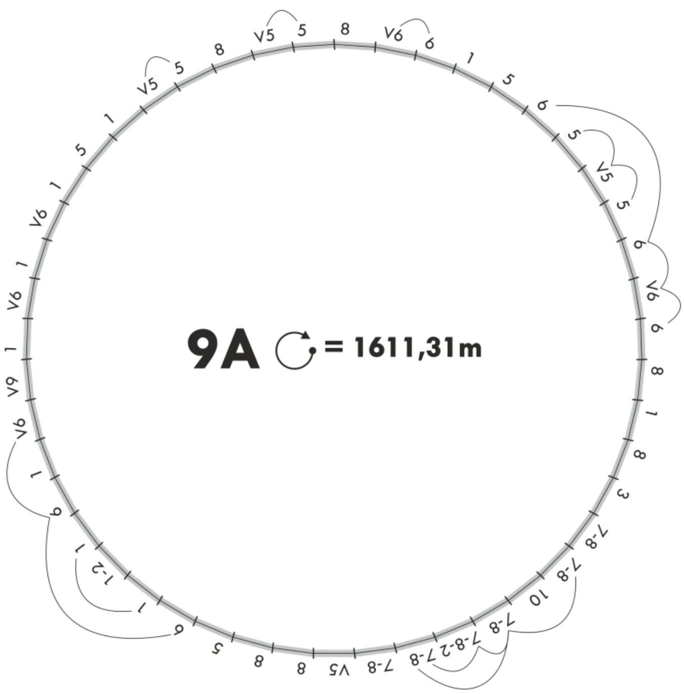

Fig. 9.7: Clock diagram of a Chunchucmil Type 9 (9A)
This diagram represents the same subdivision as centralised in **Fig. 9.6**.

The clock diagram here consists of 47 sides representing the string of boundary differentiations constituting the space. These sides also separate the topological segments with a virtual partition. Excluding these 9A partakes in 42 distinct BLT combinations. The curves on the outside linking two or more topological segments indicate that although separate in the string of boundary differentiations, crossing these segments would enter one in the same subdivision on the other side, that is, they are part of the bounding of the same space. Excluding these repetitions of the same interactional opportunities, 9A borders onto 34 discrete spaces. It should be noted that the curves linking occurrences of a Type 7 partaking in BLT combinations refer to the hierarchically superseding space created by its enclosure, while the larger curves divide the two discrete spaces (the 7-8-2 from the 7-8s) at once enclosed and bordering 9A separately. Including the enclosure separately means 35 discrete spaces border 9A. The total length of the string of boundaries bounding 9A is 1611.31m.

With this information extracted from the BLT map, it is possible to calculate some of the socio-spatial characteristics this implies. Referring primarily to the section on the dimensional context in **Chapter 8**, this diagrammatic representation of the data allows calculations on differentiation over length. To make the results of this exercise more worthwhile, however, first a number of clocks is produced for additional spaces. As indicated in the introduction to this chapter, these spaces are selected on the basis of their expected roles in ‘open circulation’ or traversability of the site: Types 9, 6, and 5, the definitions of which in **Chapter 5** stipulate the subdivisions formed by these can serve as thoroughfare. Although within the space available here to illustrate analytical potential, comprehensive representation may not be possible, in total three Type 9s, one Type 6, and five Type 5s (relative locations become pertinent later, and can be inspected on **Figs. 9.17** and **9.19**) have been selected to approximate the proportion of the quantity of these BLT identifications in the Chunchucmil test case area (**Figs. 9.8-9.11**).

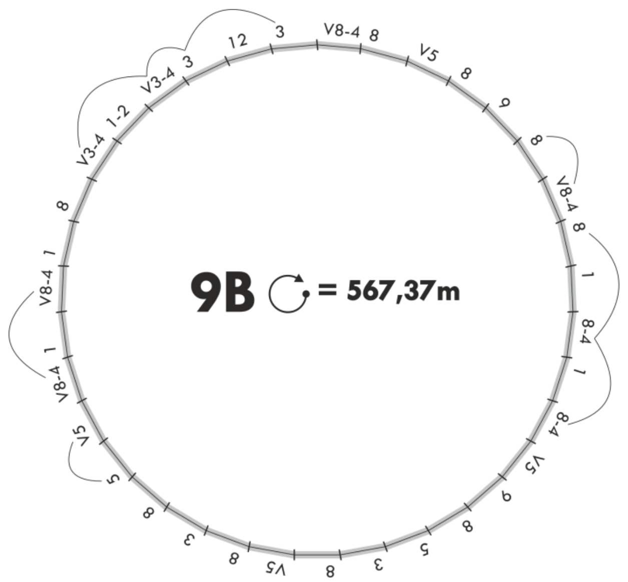

Fig. 9.8: Clock diagram of a Chunchucmil Type 9 (9B)

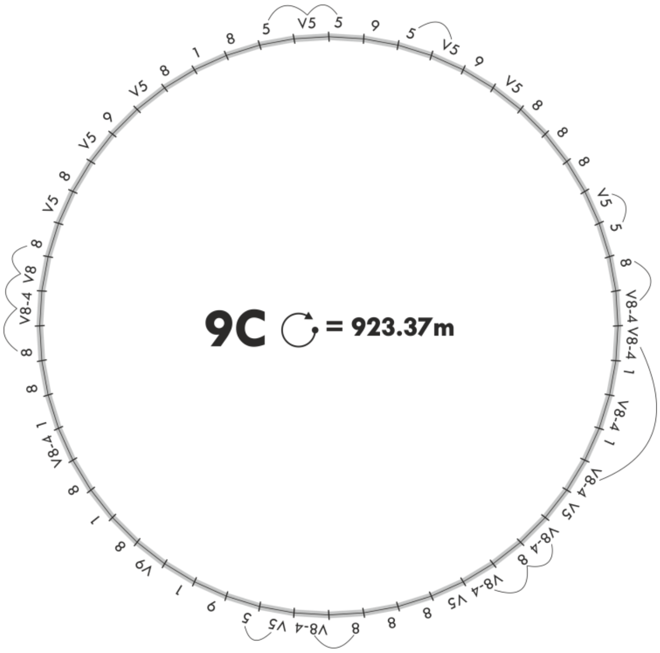

Fig. 9.9: Clock diagram of a Chunchucmil Type 9 (9C)

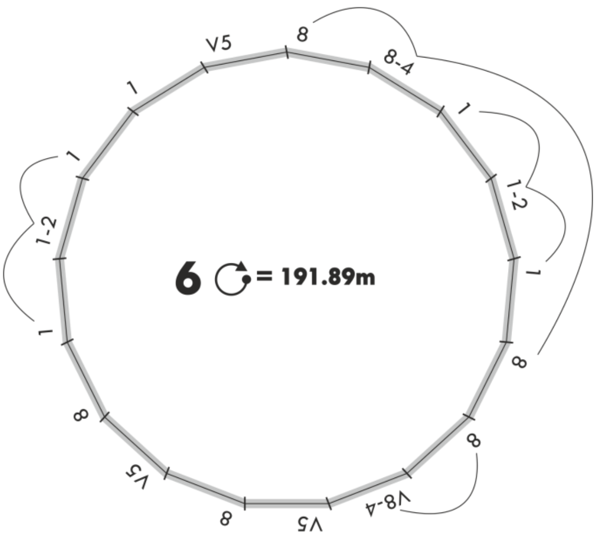

Fig. 9.10: Clock diagram of a Chunchucmil Type 6

From the clock diagrams the following table (**Table 9.2**) of calculations of topological segments over the length of the boundary circumscriptions can be derived. In order to better appreciate the calculations over length in **Table 9.2**, **Fig. 9.12** displays the relative sizes of the BLTs under scrutiny here. This gives an immediate impression as to how the average distances between boundary differentiations should be regarded. Boundary differentiations express the possibility to change interactional opportunities by crossings the topological segment. This change could either be contextual (if the boundary is one between two of the same BLTs), or an actual change when the opportunities on the other side are socio-spatially differently characterised.

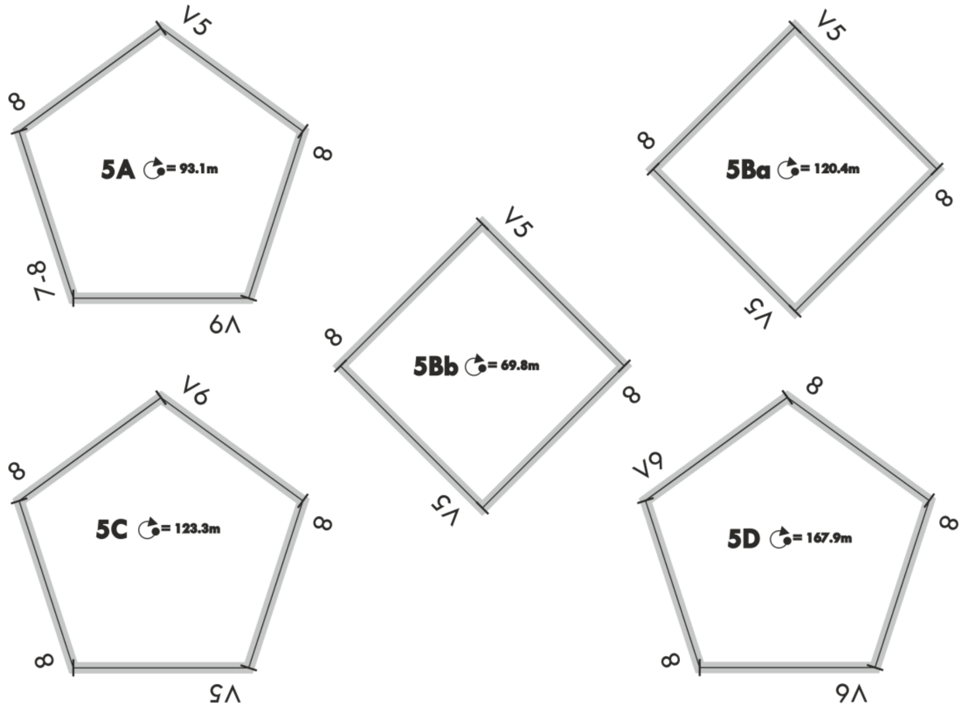

Fig. 9.11: Clock diagrams of Chunchucmil Type 5s (5A-5D)

Understanding the numbers in **Table 9.2** in the light of **Fig. 9.12** becomes more revealing. Unsurprisingly the largest example, 9A, also has the largest distance between boundary differentiations, but at the same time the much smaller 5Ba and 5D are not far behind. Although larger than all Type 5s, 6 is clearly the most intensely differentiated boundary. Relatively speaking, 9B, 9C and 5Bb are all quite close together, despite considerable differences in size. When corrected for the discrete bordering spaces, logically the distances grow as the frequencies diminish. 9A still strongly retains the largest distances, while 9B, 9C and 6 taken together grow closer together. It is also revealed that instances of virtual partitions play the greatest roles in 9A and 9C. This possibly expresses the transitional character of the two largest spaces in this selection, but at the same time could indicate how building a materially emphasised boundary along the border of such large spaces is deemed less important. It should be noted however, that these averages may not be particularly meaningful when related back to the irregular shapes they have in the actual topography of the city. The clock diagrams cannot express the relative lengths of each topological segment, which would be an improvement. A recently developed suite of circle based visualisation software for the human genome, Circos (Krzywinski et al. 2009), would potentially be able to do this as well as perhaps even automate some of the processes of drawing clock diagrams if it could be adapted to communicate with the BLT GIS data.

Frequency of boundary differentiation over length in metres									
Clock number	9A	9B	9C	6	5A	5Ba	5Bb	5C	5D
All segments	34.3	16.2	17.8	11.3	18.6	30.1	17.5	24.66	33.58
Corrected for virtual partitions	38.4	17.7	23.1	12.0					
Corrected for spaces	47.4	21.0	23.7	19.2					
Aggregated sequence length					33.68			Id.	33.58

Table 9.2: Boundary differentiations along the length of BLTs in Chunchucmil
This table shows the average distances between boundary differentiations along the length of the selected BLT circumscriptions in Chunchucmil.

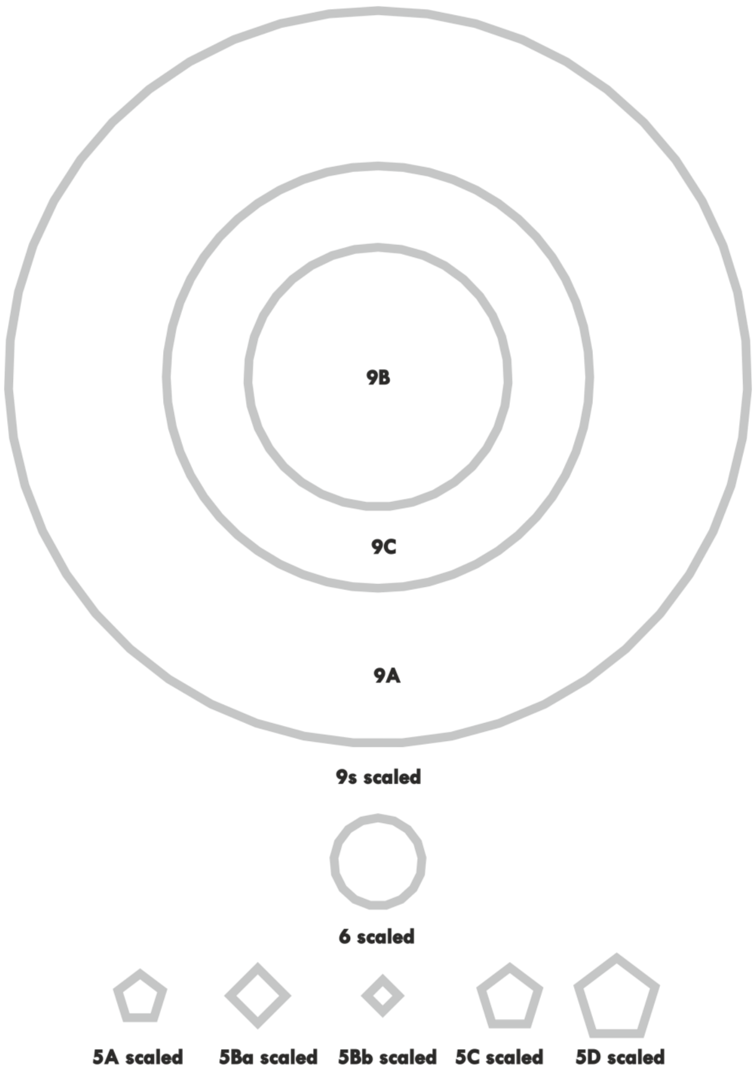

Fig. 9.12: The relative scale of the BLT lengths selected from the Chunchucmil test case
It is the size of the figure representing each BLT rather than the length of their lines that is scaled.

The final row in **Table 9.2** appeals to the aggregative dimension discussed in **Chapter 8**. 5A, 5Ba and 5C appear as a sequence in the layout of the city, only separated by virtual boundaries. When calculating the average differentiation over length across these three Type 5s it turns out the differentiation density is 33.68m, which is remarkably close to 5D, which is a stretch of road continuing the sequence after having passed 6. 5Bb is splitting off from 5A and is part of another sequence. Despite the inclination to tentatively conclude ideas about human measures of distance from such an observation, it should be stressed that the width of these *callejuelas* (alleys or 'corridor') determines part of this variable. Not only would a proper study require that many more Type 5s and sequences would be checked, overall it might be important to combine this BLT characteristic with actual metric distances of centre-lines.

Traversability and routes

Clock diagrams are more versatile than just as indicators for a density of differentiations over length. Since we are dealing with BLTs that were preselected on their possibility to serve as thoroughfare, extracting information about the diversity of choice to traverse the BLT constituted subdivisions is a next step. **Figs. 9.13-9.16** show the clock diagrams displaying the pattern of route choices to traverse 9A, 9B, 9C and 6. The Type 5s are excluded as their directing nature necessarily results in a linear pattern across.

The BLTs previously identified for their likeliness to be involved in traversability have been put in bold font and lines. The pattern in white expresses the pattern of choices to traverse across each respective BLT circumscribed space, while the sides of the polygons still express the topological segments involved in such crossing. The virtual partitions and virtual versions of topological segments are always places affording easy traversability, but one should bear in mind that doing so could be a social faux pas. Similarly, boundaries for which material evidence exists that obstructs crossing, even though they involve a combination of types likely to be involved with traversability, are excluded from the choice opportunities (grey areas).

It is immediately clear that in contrast to Type 6 in **Fig. 9.16**, the Type 9s redeem their suggested position within the circulation system. Even when excluding the virtually bounded options, choice in each instance is greater than for the Type 6. The choices across the Type 9s are also more widely dispersed along the boundary's length, emphasising the multi-directionality of their probable function in the urban circulation system. However, these multiple directions do not necessarily represent geographical space, but rather socio-spatially distinct directions. 9C demonstrates the largest proportion of its boundary affords ready crossings and through movements and 6 the least. Considering Type 6 is a disclosing boundary, thus emphasising its transition towards the socio-spatial seclusion of buildings, this is not surprising, although there are only two buildings orientated towards the Type 6 in this instance. Nonetheless, its distinct character as a place of inclination toward buildings is supported by the limited multi-directionality of traversability, which makes it easier to gather in front of buildings.

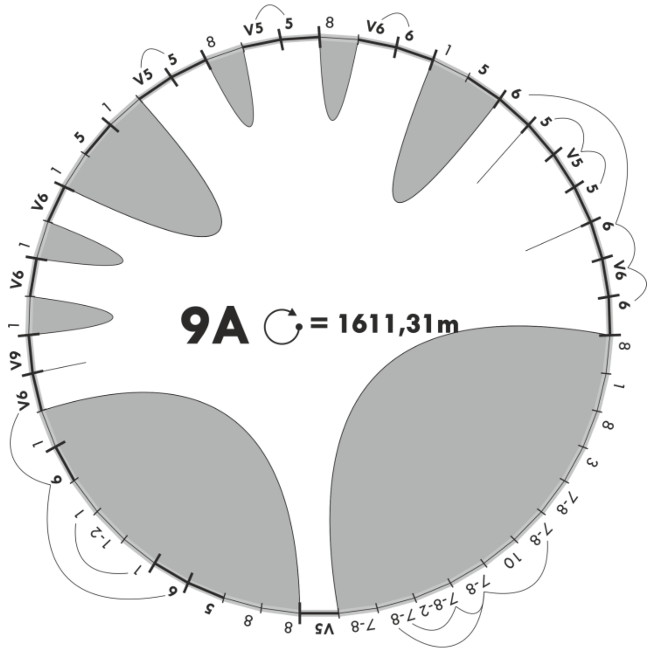

Fig. 9.13: Traversability clock diagram of Chunchucmil's 9A

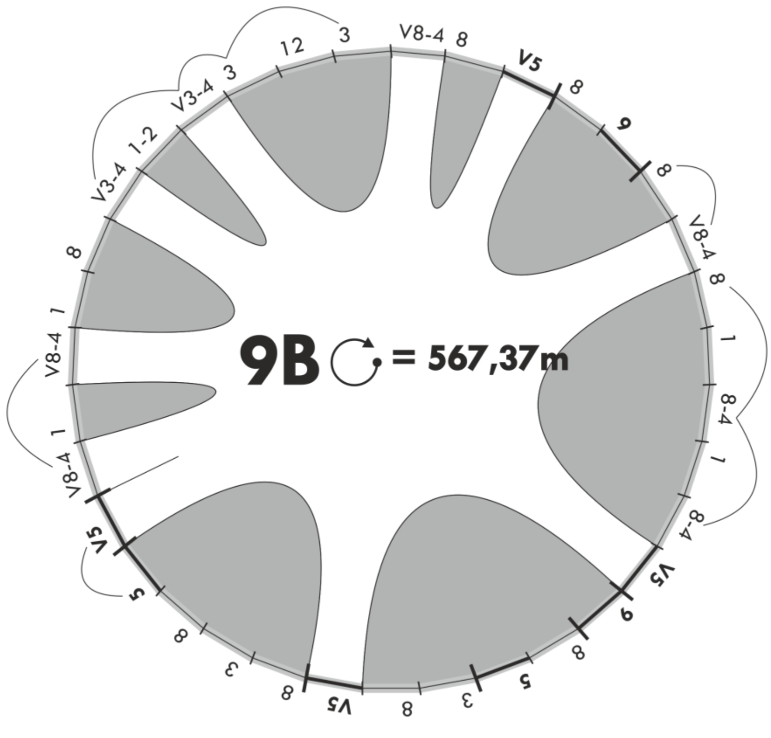

Fig. 9.14: Traversability clock diagram of Chunchucmil's 9B

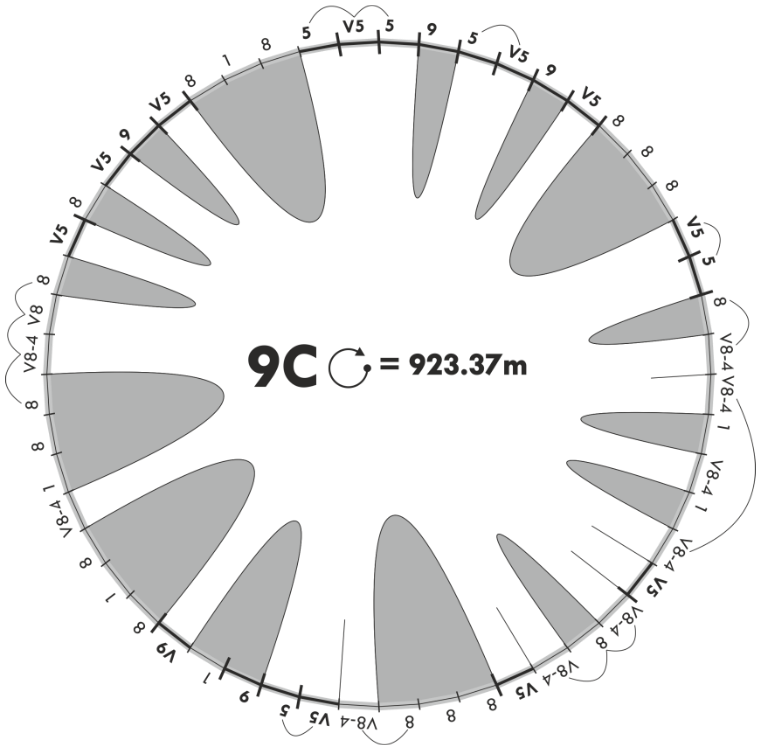

Fig. 9.15: Traversability clock diagram of Chunchucmil's 9C

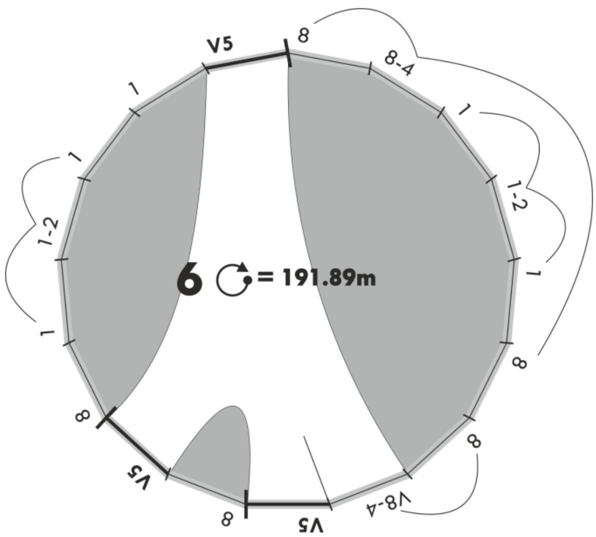

Fig. 9.16: Traversability clock diagram of Chunchucmil's 6

Table 9.3 applies the density of differentiation over boundary length to the selection of topological segments creating traversable opportunities and entrances (topological segments involving Types 2 and 4), the latter because socio-spatially speaking people could always solicit access to the socio-spatial system occupying the space constituted behind the entrance. Although the distances calculated refer to different topological segments, in the case of Type 6 the number of opportunities is equal in each case (see **Fig. 9.16**), hence the repetition of the same value. Again 9A is constituted by the greatest stretches without relevant differentiation. The very high values for 9A when looking at entrances indicate that 9A clearly did not accommodate a variety of direct relations to other more secluded socio-spatial systems: only two entrances appear along its boundary. While looking at entrances, the density relation between 9B and 9C as first manifested in **Table 9.2** is maintained, but reversed when considering traversable options and spaces, which expresses the clearly visualised multi-directional choice of **Fig. 9.15**.

Frequency of boundary differentiation over length in metres									
Clock number	9A	9B	9C	6	5A	5Ba	5Bb	5C	5D
Per traversable opportunity	146.5	56.7	46.2	48.0					
Per traversable space	161.1	70.9	51.3	48.0					
Per entrance	805.7	63.0	102.5	48.0					
Entrance corrected per space	805.7	94.6	131.9	48.0					
Entrance corrected per complex	805.7	113.5	131.9	48.0					

Table 9.3: Boundary differentiations along the length of traversable BLTs in Chunchucmil
This table shows the average distances between boundary differentiations along the length of the selected BLT circumscriptions in Chunchucmil specified for traversability.

Logically traversing space in a chain of boundary crossings constitutes a socio-spatially characterised route. This refers back to **Chapter 8**'s locational context. Again, the selection of the BLTs under scrutiny here, allows us to construct an origin-destination path from the sequence they are in: 9A-5A-5Ba-5C-6-5D-9B. **Fig. 9.17** shows the approximately 300m route on the BLT map, whereas **Fig. 9.18** reorders and rotates the clock diagrams of **Figs. 9.7**, **9.8**, **9.10**, and **9.11** so they diagrammatically symbolise the same route, crossing the topological segments where the BLTs meet as socio-spatial interfaces.

So at the basis our origin-destination path consists of the following boundary crossings (cf. **Chapter 8**): V9-5; V5-5; V5-5; V5-6; V6-5; V5-9. While the order of BLT combinations may analytically not matter, after all, the nature of the combination is the same regardless of the order, it does make somewhat of a difference when a position is known towards a boundary, as in origin-destination paths. That is, here the first crossing is from an inner 9 and outer 5 to an inner 5 with the prospect to an outer 5 and reflecting a now outer 9 if one were to regress. The order thus expresses the difference in socio-spatial situation the person following the origin-destination path will go through. That brings us to consider the broader nature of assessing possible origin-destination paths, which is the progressive and accumulative change in afforded and affective interaction opportunities.

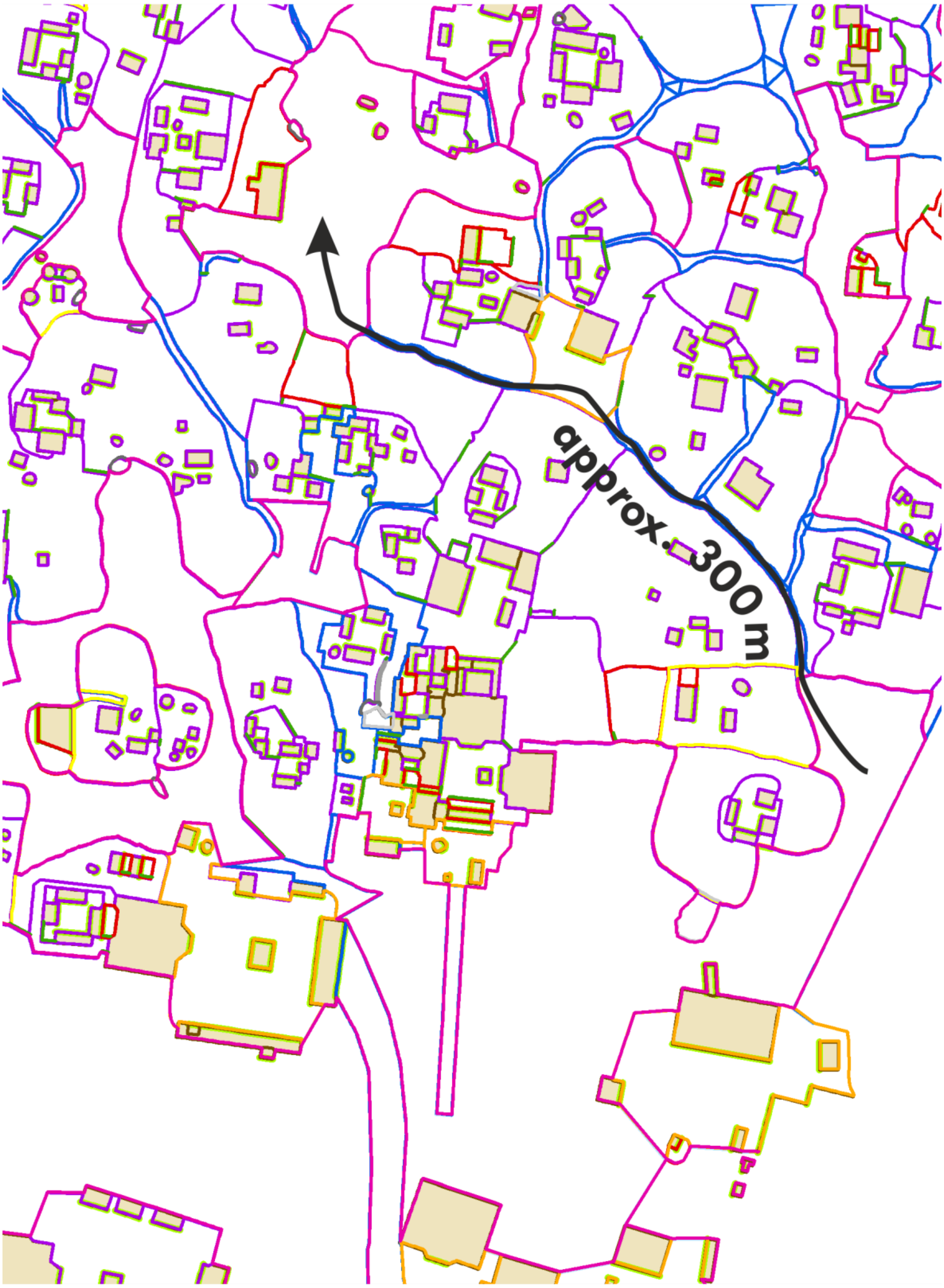

Fig. 9.17: Section of the Chunchucmil BLT map displaying the 300m route from 9A to 9B (Image prepared upon original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

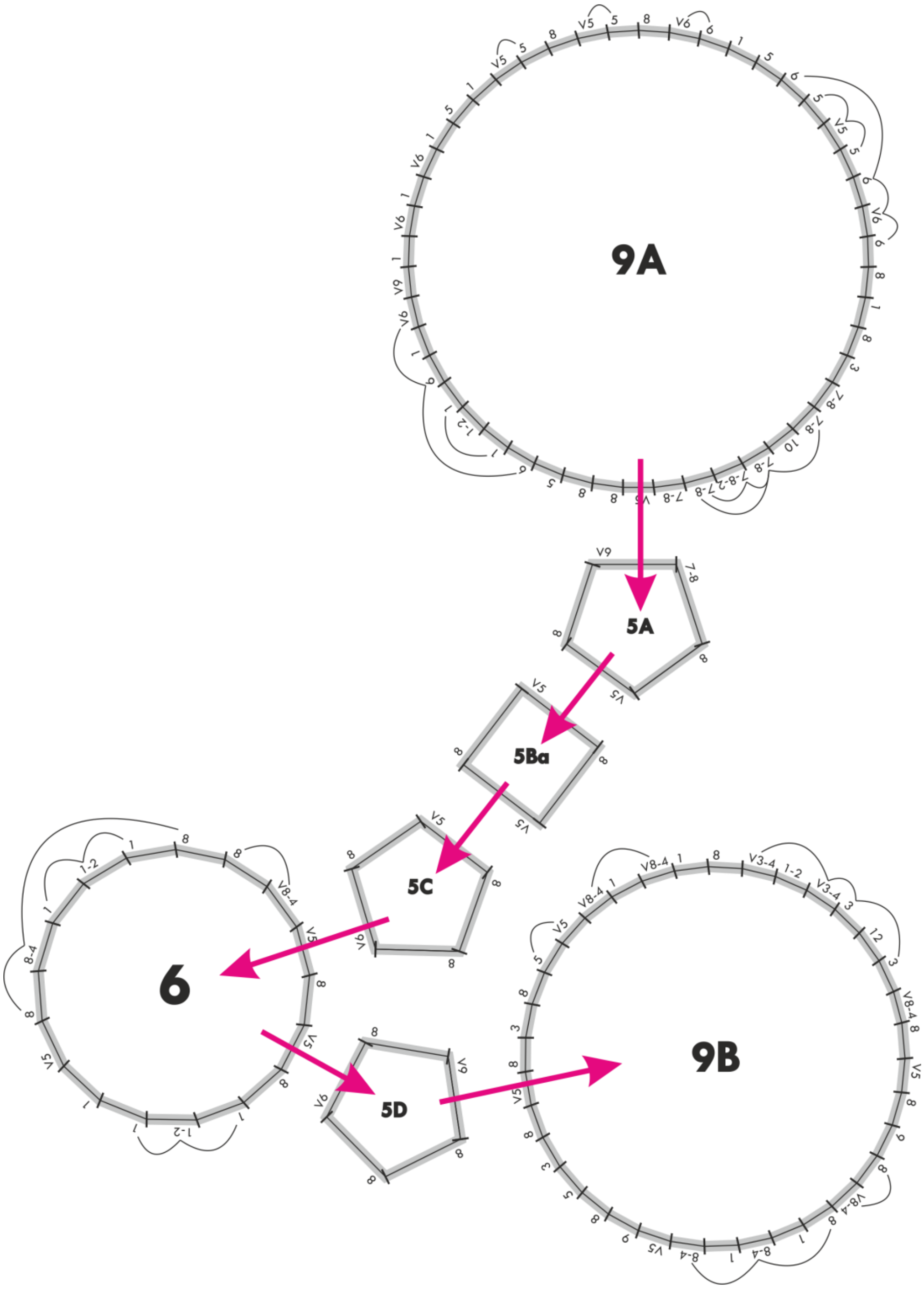

Fig. 9.18: Origin-destination path as a sequence of clock diagrams
The route across Chunchucmil from 9A to 9B represented by the sequence of relevant clock diagrams. Potential splits of directions in callejuelas take place in the virtual spaces between 5A and 5Ba, and 5Ba and 5C.

Placing the current origin-destination path into context, simple panning around the Chunchucmil test case area with the circulation prone Types 5, 6, and 9 switched on lets transpire that Type 5s (predominantly callejuelas) are often used to connect up two Type 9s or alternatively lead to a specific configurative complex based on one or multiple dominants. Taking Type 5 and Type 9 together, it seems at first glance that the entire test case area is connected up (**Fig. 9.19**). Despite the conspicuous position of the selected Type 6, seemingly playing a greater role in circulation than other Type 6s in this subset, this space could be avoided using the infrastructure of Types 5 and 9.

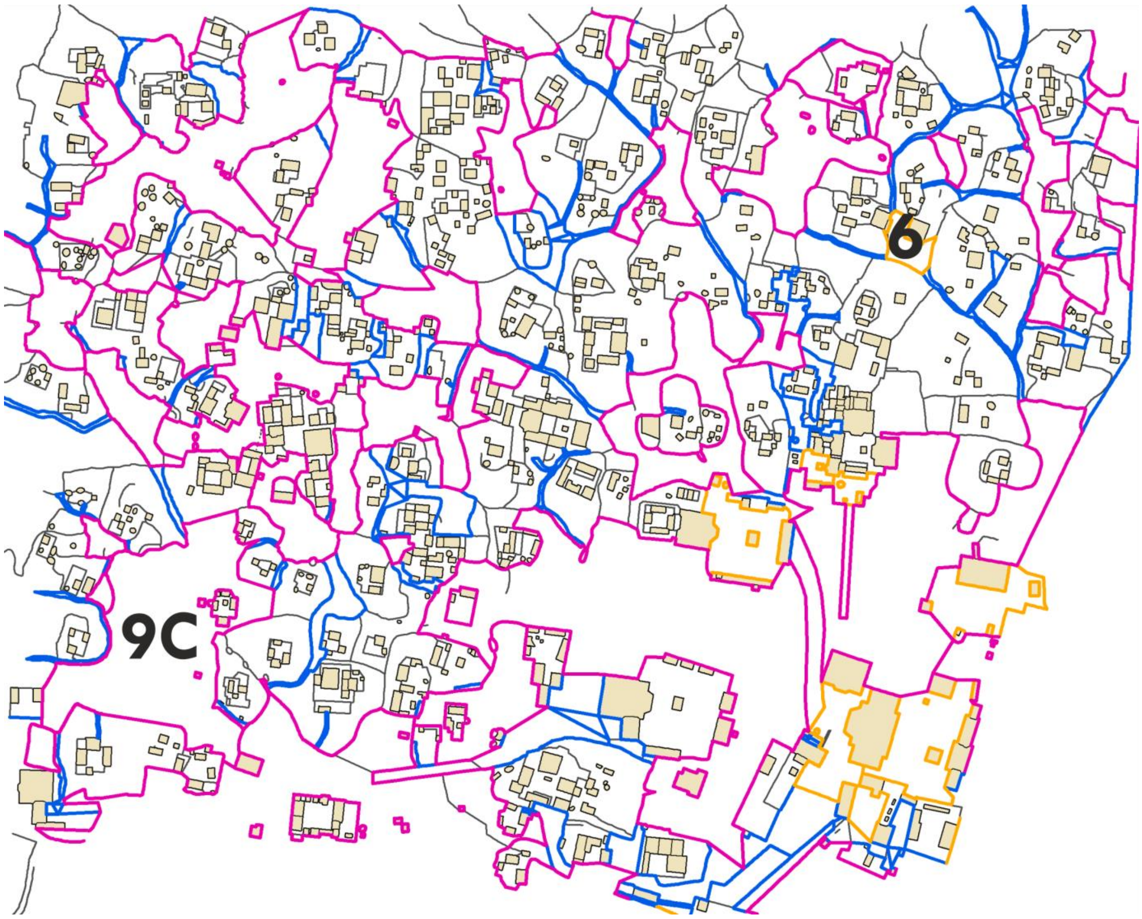

Fig. 9.19: Visualisation of the structure of Chunchucmil's infrastructure
This shows Chunchucmil's 'infrastructure' of connectivity by Types 5 (blue) and 9 (pink), with Type 6 (orange) also highlighted to contrast the position of the indicated Type 6 to the others. Note that the monumental core is located towards the lower right (southeast) of this area. 9C is indicated to position in contrast to the route of **Fig. 9.17**. (Image prepared upon original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

As a contextual aside to the origin-destination path, is can be noted that all Type 6s in **Fig. 9.19** are located in close approximation to each other. Using the general statistics as described above on the basis of this single BLT, reveals that Type 6s only occur in a rectangular area that covers 26% of the total rectangular area of the dataset. Calculating the length density of the topological segments involving a Type 6 operation over the total rectangular area related to the rectangular area in which only these topological segments occur, makes clear that within the test case area these are among the ones that show the strongest localising effects (i.e. highest ranking topological segments).

Especially when such calculations can be combined with (clustered) geographical distributions (see **Fig. 9.19**), such a quantitative indicator could be used to specify the socio-spatial patterns which may reflect neighbourhood effects. Our path, roughly speaking, leads out of this potential neighbourhood.

Allowing some speculation on the basis of the preceding observations, the movement along this origin-destination path could be imagined as follows. Entering the callejuela the opportunities to do something other than moving through are very limited. One might wave at people occupying bordering Type 8s where the albarradas allow. At the next two crossings one might expect further pedestrian traffic, although the effect of the second crossing is more limited due to its proximate destination complex. Passing through the next crossing one might get distracted by or even partake in some activities proper to the Type 6 socio-spatial system more specific to centralising thoroughfare and related to the specific functions of the disclosed dominants. After which crossing into the callejuela opportunities dwindle again, though passing pedestrian traffic could already alert one to the possibilities that lay ahead. Finally, the destination, 9B, is reached. Logically, assuming this is an actual origin-destination path, relating to different activities undertaken by the actor, at this point one would want to know how, from A to B, the actor's socio-spatial situation of afforded opportunities has changed. For this we need to move beyond the realms of density and accessibility glossed so far (cf. Marcus 2007, 2010; **Chapter 8**) and introduce a context of relative frequency and diversity.

Frequencies and diversity

Because the origin-destination path defined before (**Fig. 9.17**) leads from one Type 9 to another, the example of relative frequency and diversity of BLT combinations presented here focuses on the selected Type 9s. First, however, the frequency and diversity for which the Type 9s are responsible in comparison to all selected BLTs (**Tables 9.2** and **9.3**) should be put in context. **Fig. 9.20** presents an adapted clock diagram representing this subset of BLT data. The sides represent all different topological segments which together constitute the selected Types 5, 6, and 9, the columns represent the frequency count of their occurrence.

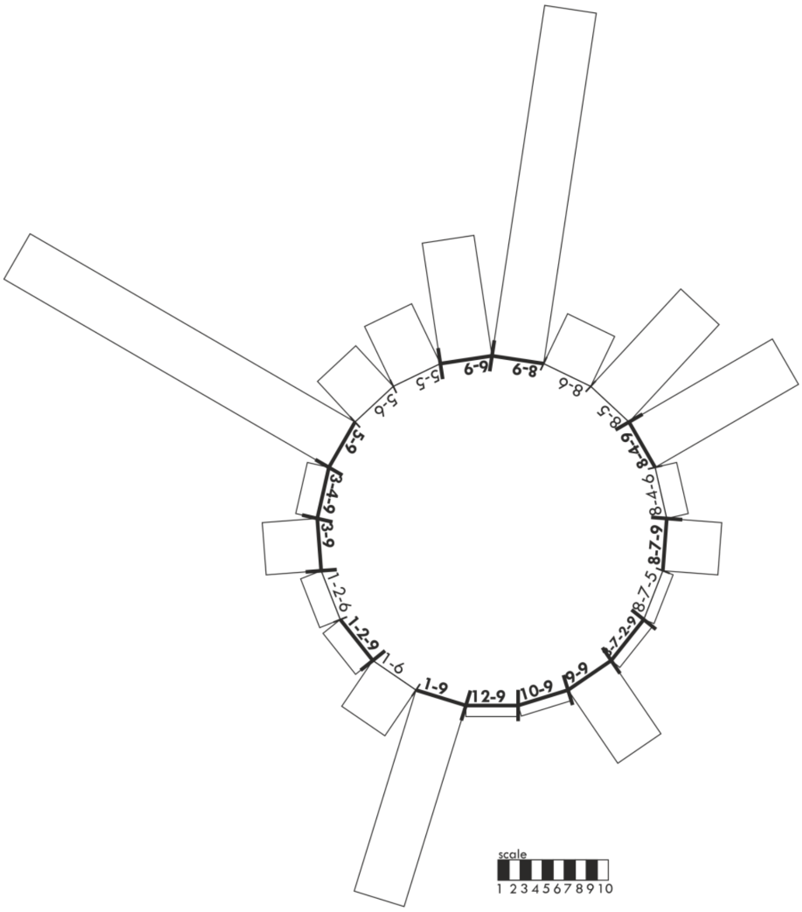

Fig. 9.20: Scaled frequency clock diagram of topological segments in Chunchucmil
This scaled frequency clock diagram displays all topological segments in Chunchucmil's selected BLTs. The centre represents an aggregate of all selected Type 5, 6, and 9 circumscriptions.

The original clock diagrams (**Figs. 9.7-9.11**) clearly show that more topological segments partake in the constitution of the Type 9s than any of the others. **Fig. 9.20** demonstrates that it also applies that the Type 9s are responsible for most of the topological segment diversity in this selection (13 out of 21 possibilities). This makes Types 9 on the basis of this subset socio-spatially more diversely constituted, which especially in combination with their size (see **Fig. 9.19**) suggests they could have served multiple functions associated with their boundary diversity and within the city as a whole. This information is indicative of patterns in the aggregative dimension of **Chapter 8**.

If we further specify our selection to the socio-spatially constitutive pattern of Type 9s we can create a frequency clock diagram that displays the average topological segment diversity per Type 9 identification (**Fig. 9.21**), which may form a base for expectations about further Type 9s.

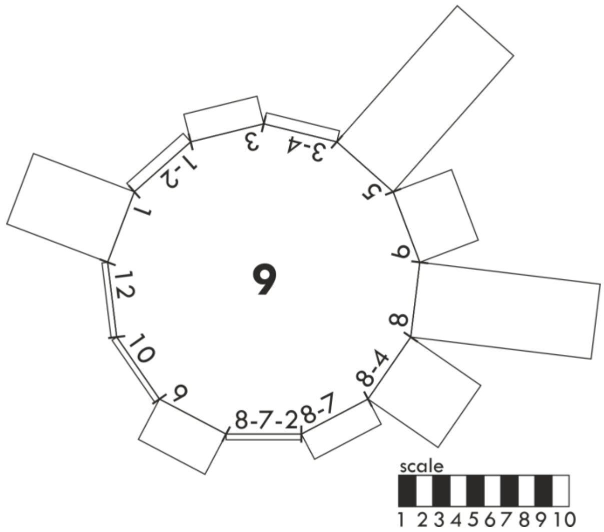

Fig. 9.21: Frequency clock diagram displaying the average diversity taken across 9A, 9B, 9C

From this we can see that the majority of Type 9 boundary operations relate to the operations of Types 8 and 5. It also clear that although a relatively large number of Type 1s (thus buildings) are part of Type 9 operations in Chunchucmil, it is fairly rare to find an entrance to them from this side. While in the discussion of 9A earlier it was remarked that its constitution showed little direct engagement with boundaries related to complexes involving dominants, **Fig. 9.21** demonstrates this may be out of the ordinary in comparison to 9B and 9C, possibly due to their relative position further away from the monumental core (see **Fig. 9.19**). This finding can be illustrated using the frequency clock diagram in a relative manner (**Fig. 9.22**).

9A's diagram shows that contrasted to the average there is not only a conspicuous absence of topological segments involving Type 8-4 combinations, but also an underrepresentation of combinations involving Type 8, indicating that 9A is socio-spatially speaking more distant from dominant complexes with shared plots, which are known to be a common residential pattern (Magnoni et al. 2012). Instead, 9A is very well connected to disclosing boundaries (Type 6s), which consolidates its transitional position between the more building specific functions likely to take place beyond those boundaries. When referring back to its original clock diagram (**Fig. 9.7**), looking at the order or rhythm of topological segments, it is revealed only one Type 6 circumscribed subdivision (occupiable space) is not also directly neighbouring one or more buildings. This further clarifies why, despite numerous connections to buildings, inhabitants would be expected to cross into the designated disclosing boundaries first. The underrepresentation of Type 8 involvement is also assessed more clearly by looking at the topological segment order, which reveals that most Type 8s along 9A's boundary are concentrated on a relatively small stretch of boundary line, thus located in socio-spatial proximity to each other.

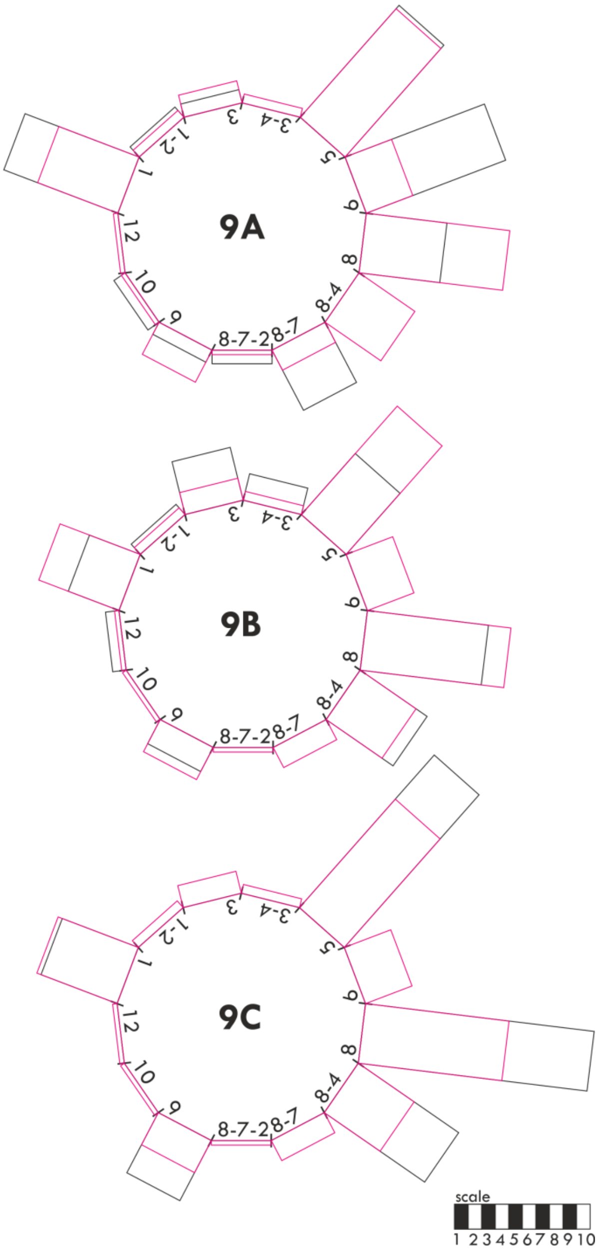

Fig. 9.22: Scaled frequency clock diagrams of Chunchucmil's 9A, 9B, and 9C
These scaled frequency clock diagrams of 9A, 9B, and 9C display the relation between their individual topological segment diversity counts (black) and their combined average (pink).

In contrast, 9C dramatically over-performs in connecting to such Type 8 combinations and is also better connected for through movement in various directions (Type 5s), which reinforces what **Fig. 9.15** already indicated. While 9B may be worse connected with regards to movement, this seems to result primarily from an overall better connection to direct entrances (Type 3-4, 8-4, and 1-2 combinations), which further specifies the quantitative pattern indicated in **Table 9.3**. Finally, the above glossary of Type 9 diversity tells us a little more about the possible purposes of our hypothetical origin-destination path. Originating from a clearly transitional 9A, the inhabitant moves along a few traffic corridors and passing an area accommodating more specific functions (Type 6) to arrive at a location which would likely have formed the final boundary before solicitation for access (requests and visits) to more secluded socio-spatial systems. While, as discussed in **Chapter 6**, what actually occurred cannot be concluded from BLT analyses, and it therefore cannot be precluded that e.g. the inhabitant had further to travel along one of the bordering Type 5s, 9B itself is more conducive as a location for activities to which some of the bordering more secluded individual or groups of dominants had stronger purchase and which could have formed a destination for inhabitants beyond.

This brief discussion on the diversity of Type 9s taken together to compare internally, suggests that adding and combining an increasing number of observations implicates rather precisely (due to systematic application of formal concepts) the socially functioning roles accommodated by the constitution and composition of each of these boundaries. Nonetheless, within this particular and limited subset the strongest conclusion is the large variety in the nature of Type 9 operations. The nature of their diversity could form directions for further research.

Accessing size

As a final example based on the Chunchucmil test case the BLT analysis will be combined with a much more morphological consideration of size. Rather than replicating the study of Magnoni et al. (2012), this example will briefly look at size related to access. The observation made above on 9A's under-involvement with Type 8s becomes particularly striking in the light of size. Subdivisions resulting from Type 8 identifications could be as big as those resulting from Type 9s (even though the maximum surface area for Type 9s is much greater still). **Fig. 9.23** makes it immediately clear that in fact, subdivisions with an inner Type 9 or 8 circumscription, represent the vast majority of the occupiable surface area in Chunchucmil's test case. Supported by the general statistics, Types 9 and 8 partake in an impressive 89% of the boundary topology's length, 86% of the count, and over half the socio-spatial diversity. In other words, they play a strongly determinant constitutive role in the social functioning of Chunchucmil.[129] **Fig 9.23** confirms that the Type 8s involved with 9A are all located in the north, and fairly close together in both the geographical and socio-spatial sense. Furthermore it can be seen how 9A's situation within the whole is distinct from the other Type 9s, the boundaries of which are all very tightly knit with Type 8s.

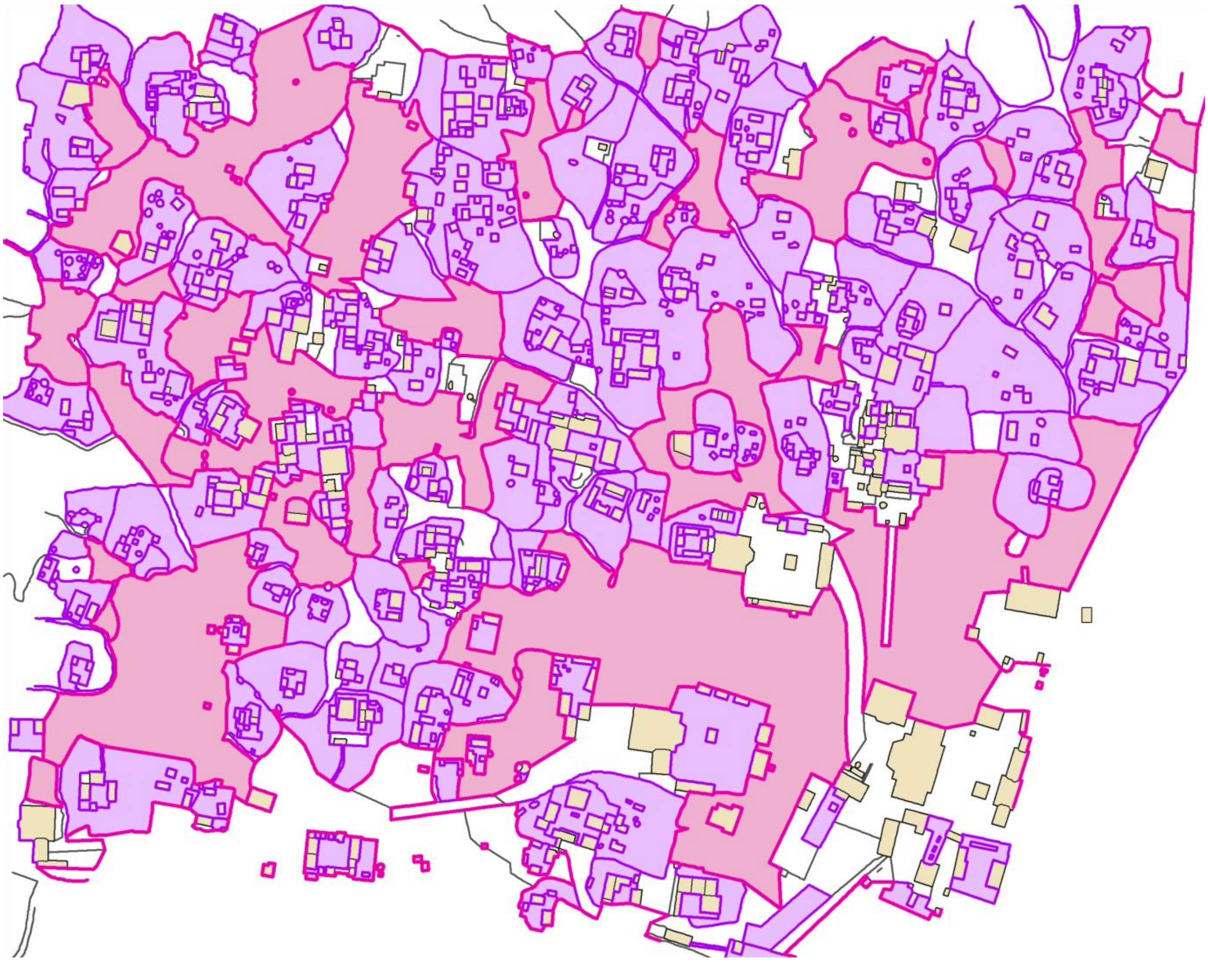

Fig. 9.23: Visualisation of the general coverage of Chunchucmil's Types 8 and 9
These are the surfaces of the subdivisions created with Types 8 (purple) and 9 (pink) inner circumscriptions in Chunchucmil's test case area, virtually covering the entire area. (Image prepared upon original data, courtesy of the Pakbeh Regional Economy Program with help from S. Hutson.)

If we speculate about the presumably more static occupation of buildings and shared plots (i.e. these more secluded complexes is where one would expect activities with longer duration, such as dwelling and production) by Chunchucmil's population, which is estimated to be notably large amongst its Maya urban peers (cf. Magnoni 2007;

[129] In contrast, Types 8 and 9 partake in 28% of the topology's length, 20% of the count and less than half the socio-spatial diversity in Winchester. Despite Winchester's 2.5 times higher density of socio-spatial differences, Types 8 and 9 operations combined feature a denser occurrence in Chunchucmil than in Winchester.

Hutson et al. 2008), the relative pressure on space for movement and centralising activities tied to soliciting engagement with buildings (Type 7s) becomes clear. While presumably there would have been plenty of space in part determined by Type 8 or 9 boundary operations, thus for socially very open interaction to interaction concentrated on designated social subsets, secluded (private) and movement space could have been crowded.

By combining the preceding BLT visualisation techniques with the morphological variable of size, the relation between the opportunities to access discretely subdivides spaces from a position on the other side of the boundary and the size over which the anticipated socio-spatial interactions persist can be clarified. **Fig. 9.24** applies this logic to the Type 6 selected earlier.

The huge contrast in size between the shared plots constituted from within by a Type 8 and the other accessible spaces jumps out. Furthermore one of the directly accessible buildings rivals the callejuelas for surface area, but the other is the smallest space by a major margin in comparison to all other accessible spaces. From the perspective of the socio-spatial system occupying the Type 6, this means that it is closely related to a wide variety in interactionally distinct continuous surfaces. The fleeting open interactions of the directing boundaries (Type 5s) are well-represented and overall materially least restricted. Both buildings display a similar order of topological segments and materially emphasised seclusion, but will most likely have represented different social functions associated with their strongly contrasting sizes. Both Type 8-4 entrances lead to shared plots of considerable size (although as **Fig. 9.23** shows definitely not excessively large in comparison to other examples), and would likely have been functionally arranged in sections related to the buildings amongst which the open space acted as a common.

Upon closer inspection these two mutually bounded areas share a reciprocal entrance, but are otherwise externally separated by an albarrada. Such internal connections suggest that neighbourhoods could potentially be made up out of sequences of these large shared plots, creating hierarchical aggregating complexes. While BLT analysis cannot directly support arguments on the social stratification of such areas, it could thus help complement the initial exploration on the size of residential complexes by Magnoni et al. (2012), by informing how they could be grouped and giving an indication of the nature of their connection internally and how the grouping is externally defined. As suggested in **Chapter 8**, here, morphological interests in building lines, plot series, blocks, etc. seamlessly integrate with socio-spatial BLT interpretation. Similarly, the likely crowdedness of the occupation of directing boundaries could potentially be further specified and hypothesised with movement oriented space syntactic correlations.

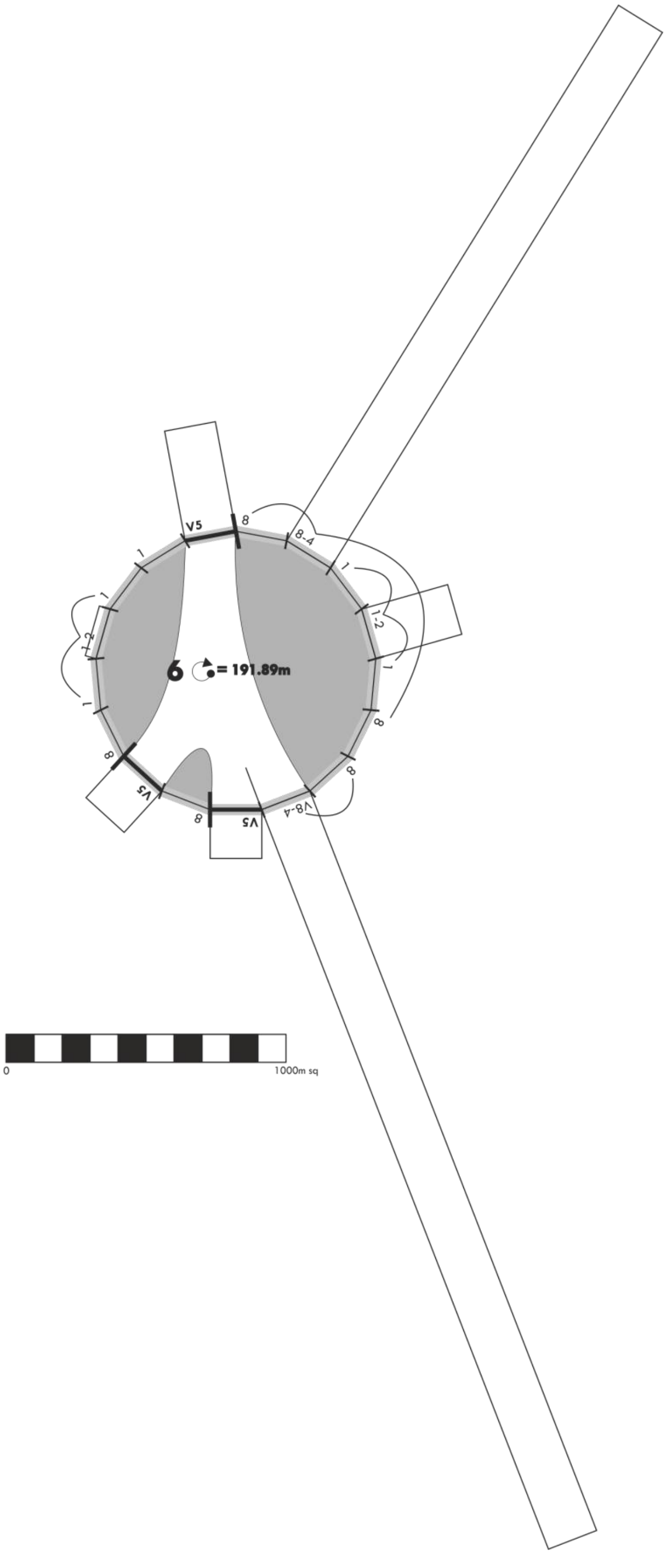

Fig. 9.24: Traversability clock diagram for Chunchucmil's Type 6 with accessible space sizes

This traversability clock diagram for Chunchucmil's Type 6 is combined with the readily accessible discrete spaces connected to it. The length of the columns represents the number of square metres.

Exploring Winchester through time

Chapter 6 has discussed at length the prevalent families of methods for studying the (western) urban design tradition that, broadly speaking, Winchester is an example of. Since the BLT mapping methodology has been positioned in relation to these extant methods, it is unnecessary to review approaches to studying related examples of urban form. It should go without saying that all the analytical possibilities and tendencies based on BLT mapping and demonstrated so far could also be applied to the Winchester test case. However, instead of repeating the analytical arguments and demonstrations supported by the Chunchucmil data, this section will briefly explore how the techniques used so far could be used to support diachronic studies of the inhabited urban built environment, as time depth is the unique dimension opened by using Winchester as a comparative case. While some general comments on the comparative insights between Chunchucmil and Winchester will be made, the focus is on the diachronic merits. This also reflects that general contemporary and historical knowledge on British urbanism is much greater and still in various locations relatable to current inhabitants daily inhabitation of persistent spaces. Whereas the Maya urban tradition is virtually unknown, British urban history is presented in comprehensive historical overviews (e.g. Palliser 2000; Clark 2000; Daunton 2001). In this sense, it could be regarded as an important proof of concept if broad expectations and general knowledge is in one way or another reproduced by analysing BLT data.

Using BLT maps diachronically

BLT identifications are completely unique for each moment in the development of a city for which an atomic outline base plan representation is made, that is, unique for every time-slice. It logically follows that it is impossible to trace ‘the same’ BLT identification through time: it does not exist as such. Even when locally a situation remains the same to such extent that the BLT identifications would be largely replicated, these identifications are still a fruit of the particular material-spatial situation of that time-slice in its time-space specific context. Nonetheless, as we know from urban morphological principles that in fact much of urban space is quite resilient to change, the change of space through time could still be made subject of research through geographic approximation. As discussed in **Chapter 8** unfortunately geocomputation has yet to develop effective geometrical principles into readily usable software applications to aid with informative change detection. Therefore a more intuitive approach was followed here to demonstrate the principle of working through time.

As was mentioned in **Chapter 7** (**Fig. 7.2**), for the purposes of this research, taking the Winchester test case back through time was only applied in a limited area of approximately 175x200m. This area is located right over the bridge that in medieval times would have led to the east gate to the city. Since BLT identifications cannot be used regressively, the geographical location of the bridge was selected to base a diachronic example on, despite its change and development through time. The contiguous stretch of boundary lines that incorporates the southern edge of the bridge (see **Fig. 9.25**) was used to select circulation prone BLT identifications, which then could also be crudely compared to the earlier assessment of Chunchucmil's circulation space. The idea is to keep both the location and the length of the combined contiguous boundary lines (as the crow flies) relatively equal in all three time slices.

Going from MM to the OS1872 is relatively simple to relate, as major architectural features and infrastructural development had already taken place in the 19th century. However, it was immediately clear that a change in boundary outlines of subdivisions has logically affected the identification of BLTs on the OS1872 time-slice. This caused the subjective decision in the 21st century situation to slightly 'lengthen' the High Street that comes in from the west in **Fig. 9.25** by using the architecture of the building towards the south that still follows the direction of the High Street. **Fig. 9.26** shows the situation for the OS1872 time-slice, which demonstrates how the slight change in subdividing outlines causes such discrepancies in identification.

In order to 'fix' this discrepancy, in preparing the clock diagrams for the two Type 5s, essentially creating the topological sides (see **Chapter 8**) of the contiguous boundary line followed, an alternative course for the virtual boundary cutting the parallel direction of the Type 5 representing the High Street could be imagined. When doing so, the length as the crow flies only differs one metre from the OS1872 situation (**Fig. 9.26**) and this can undoubtedly be ascribed to the slight changes to the morphology of the road crossing the bridge towards the east as shown on the MM BLT plan (**Fig. 9.25**).

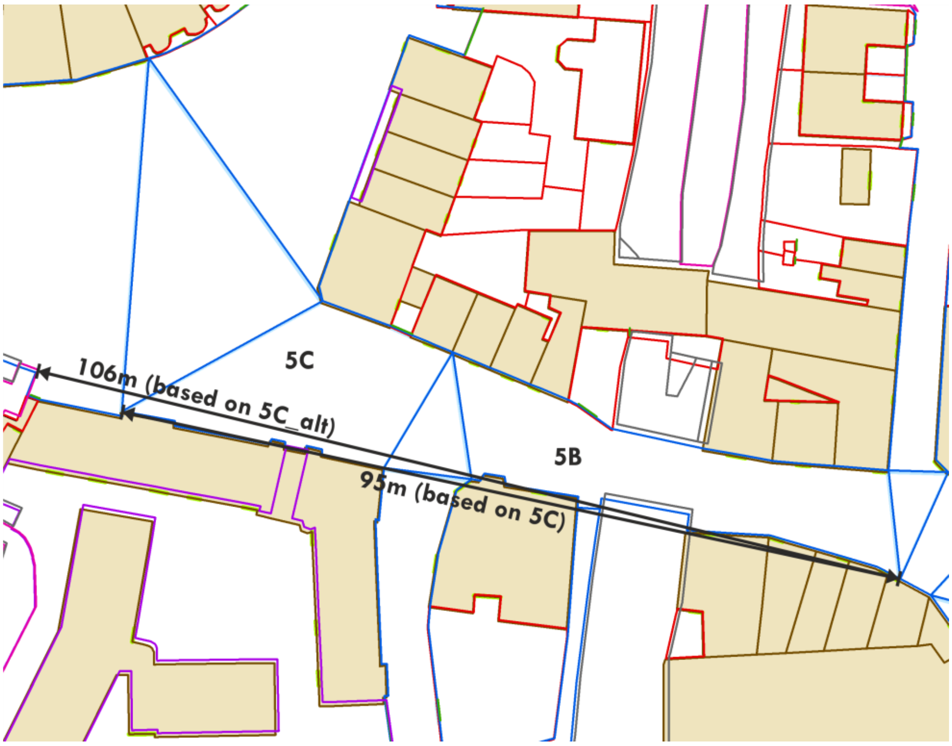

Fig. 9.25: Section of the MM time-slice Winchester BLT map
This section of the MM time-slice Winchester BLT map indicates the selection of the contiguous stretch of boundary lines incorporating the bridge. (Based on OS MasterMap. © Crown Copyright 2013. All rights reserved. An Ordnance Survey (EDINA) supplied service.)

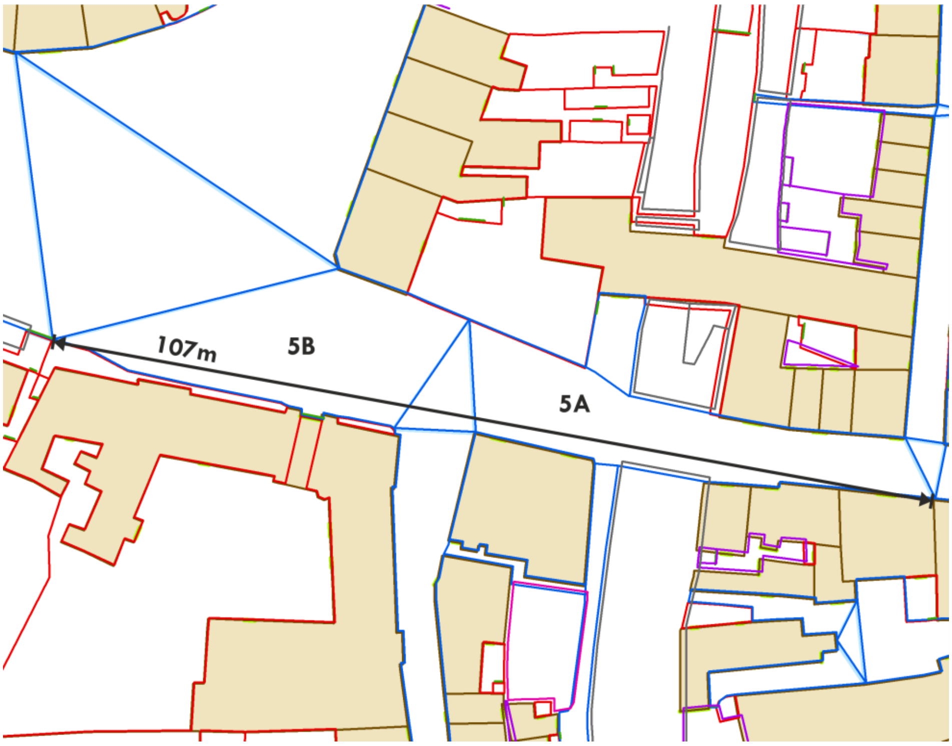

Fig. 9.26: Section of the OS1872 time-slice Winchester BLT map
This section of the OS1872 time-slice Winchester BLT map indicates the selection of the contiguous stretch of boundary lines incorporating the bridge. (Vector data derived from original scans: © Crown Copyright and Landmark Information Group Limited 2013. All rights reserved. 1872.)

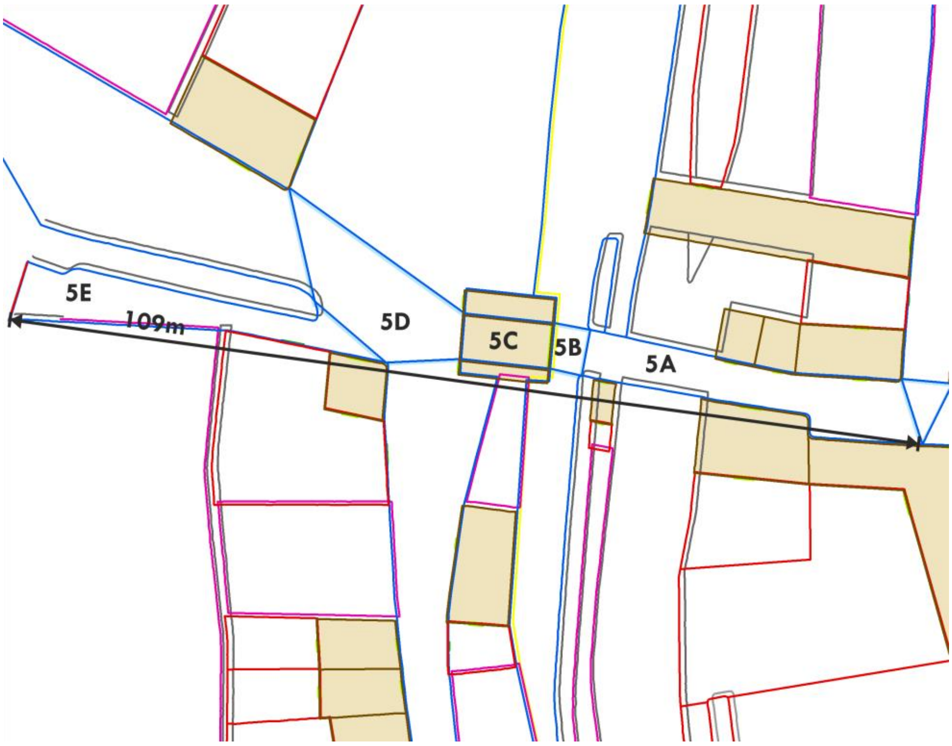

Fig. 9.27: Section of the 1550s time-slice Winchester BLT map
This section of the 1550s time-slice Winchester BLT map indicates the selection of the contiguous stretch of boundary lines incorporating the bridge. (Vector data based on original scans, reproduced courtesy of the Winchester Research Unit.)

In contrast the immediately visible morphological changes are much more dramatic from the 1550s to OS1872. The contiguous boundary line selected has grown a bit. Again, changes in the course of the street may well be responsible for this minor change as the crow flies. Moreover, the area to the west of the bridge has clearly been completely redeveloped between the 16th and the 19th century, causing a markedly different (unrelatable) endpoint there.

Quickly assessing the situation sketched in the BLT maps of **Figs. 9.25-9.27** reveals that opening boundaries (Type 9s, pink) virtually disappear from this small area from the 16th to the 19th century. The 19th century sees a growth of the number of Type 8s (purple), which may not be very large, but significantly create small subsets of buildings in the same way Type 3s (red) do across all time-slices. This finding is fortuitous as historical discourse reveals that the rapid development of the Victorian city comprised amongst other things a process of transition in which an emphasis on shared open areas shifted to increasingly individual open areas associated with residences (contextually expected to be identified as Type 3s) (Daunton 1983). This process even reached the point where planning policy was put in place for the construction of urban residences including such individual open areas. According to Daunton these changes were introduced earlier in the large cities after which they found their way into provincial towns. Winchester was such a regional town and the OS1872 time-slice seems to capture the city in the middle of this transition, with a good representation of both situations still experienced by its inhabitants. This is in fact immediately clear from the BLT mapping of that time-slice.

A main difference with Chunchucmil's urban built environment, on the other hand, is how the Type 5s do not only direct to situations leading to further interaction opportunities, but along this direction also connect up numerous strongly secluded boundary operations (especially Type 1s). While after the 16th century the settlement in the city seems to intensify in terms of closing boundaries, thus buildings, this nature of Type 5s in Winchester applies throughout. Furthermore, looking at the 1550s time-slice, various Type 9s occur, but clearly differ in the position and socio-spatial situation to those identified in Chunchucmil. These Type 9s concur with the Chunchucmil ones in that any necessary material evidence that would prevent access is largely absent. Therefore these Type 9s could also partake in the circulation of traversing Winchester. Yet, the fact that they tend to be laterally placed in relation to Type 5s, instead of head-on as is usual in Chunchucmil, suggest their open transitional character might refer to other social functions or a different contextual placement of similar functions occupying the resultant spaces.

Before moving on to the clock diagrams produced for each time-slice situation respectively, it is worth noting the obvious increase in the number of topological sides resulting from separate subdivision on the northern side of the selected contiguous boundary line in 1550s in relation to the other time-slices (numbered 5A-5E in **Fig. 9.27**). The three 'additional' Type 5 identifications result from the presence of the gate house in association with the city walls, which were removed some time before OS1872.[130] While the Type 5 directing people through underneath the gate house itself is clearly bounded, the two on either side are mainly virtually bounded due to the confluence of parallel directing boundaries ending onto these. The fascinating thing about them is the clear difference in shape and size, in seemingly similar locations. The presence of the virtual boundaries assumes particular significance by emphasising the liminality of the city wall and the spaces directly outside the gate house.

The presence of these additional emergent Type 5 subdivisions with such a porous socio-spatial definition, suggests particular use of these areas. It is easily imagined how

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[130] Actually the gate house was removed before 1750, as the Godson survey shows. However, at that time the removal of the entire wall had not progressed to the same extent.

after passing the city gate one would be greeted by an abundance of activity: services being offered, requests made, potentially duties paid, etc. The relatively oversized space emerging from the confluence of Type 5s seems to accommodate this appropriately. At the same time the much smaller but similar subdivision on the outside, may suggest the more transitory use of this area, either for passing through or bidding the relatively quick request to enter, with probably limited time spent waiting there. Alternatively, in a much more controlled environment, the process of permitting access could have been strictly organised or efficiently run in such a small area. Moreover, 5B neighbours two Type 12s, which are by definition inaccessible and therefore would literally have restricted movement. Whether still current in the 16th century or not, this looks like a remnant of a socio-spatially defensive situation, which is supported by our supplementary historical knowledge of city walls. Additionally, a bridge is an expensive construction, which means creating surface space only could become available at a premium.

Exemplifying diachronic BLT development

As indicated in the above, each time-slice implies completely unique BLT identifications. The consequence of this is shown in **Figs. 9.25-9.27** with the different shape and for 1550s also different number of Type 5s constituting part of the contiguous boundary line selected as a diachronic example here. This means that it is impossible to trace the same clock diagram through time and therefore individual diagrams for each of these time-slices need to be produced. **Figs. 9.28-9.31** contain the clock diagrams for each respective material-spatial situation depicted in the time-slice sections in **Figs. 9.25-9.27**.

We can take from the contrast between these clock diagrams that purely in terms of topological segments each individual Type 5 operation in 1550s is constituted by less differentiation, except for MM's 5C/5C_alt. By the same measure MM's 5B is historically speaking the most differentiated subdivision along this contiguous boundary line. Unfortunately, this current presentation of clock diagrams is not the most immediately intelligible way of investigating the developmental differences in socio-spatial constitution through time. To improve diachronic comparison, the topological sides caused by the currently separated subdivisions partly constituted by Type 5s should be aggregated into a representation of a single subdivision.

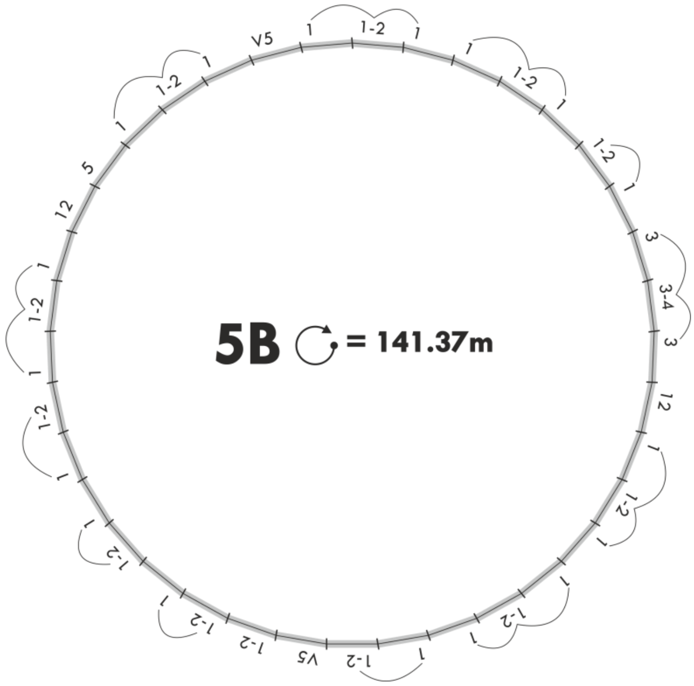

Fig. 9.28: Clock diagram for 5B in the MM time-slice (see Fig. 9.25)

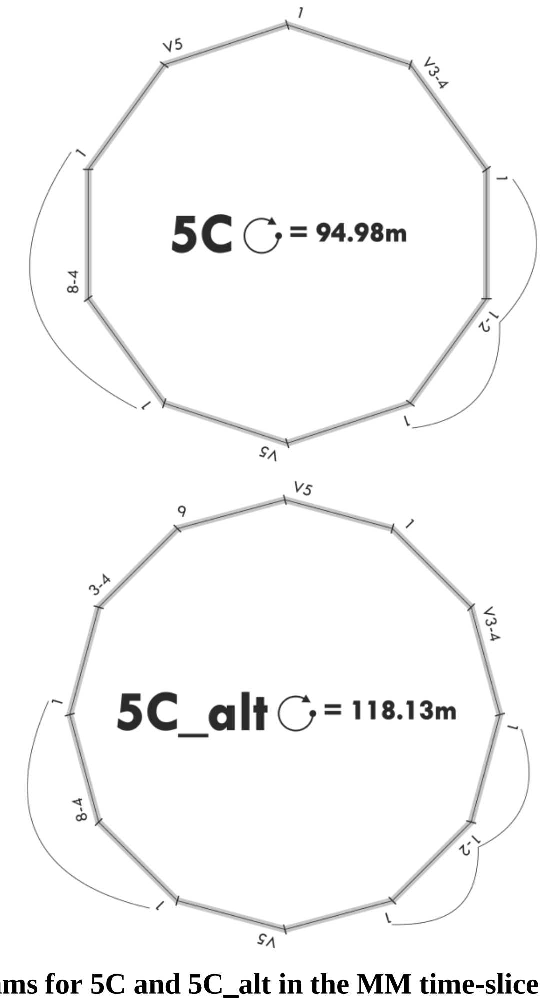

Fig. 9.29: Clock diagrams for 5C and 5C_alt in the MM time-slice
These clock diagrams comprise 5C and the imagined geographical diachronic equivalent 5C_alt in the MM time-slice (see **Fig. 9.25**).

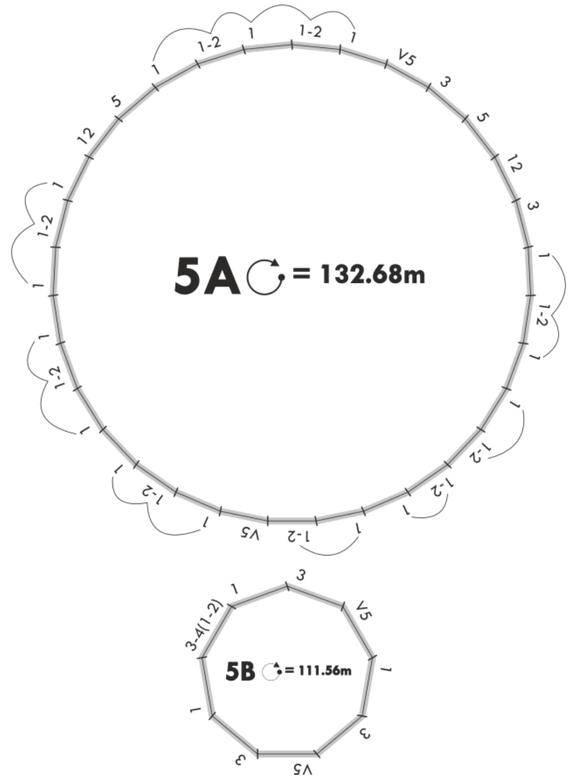

Fig. 9.30: Clock diagrams for 5A and 5B in the OS1872 time-slice (see Fig. 9.26)

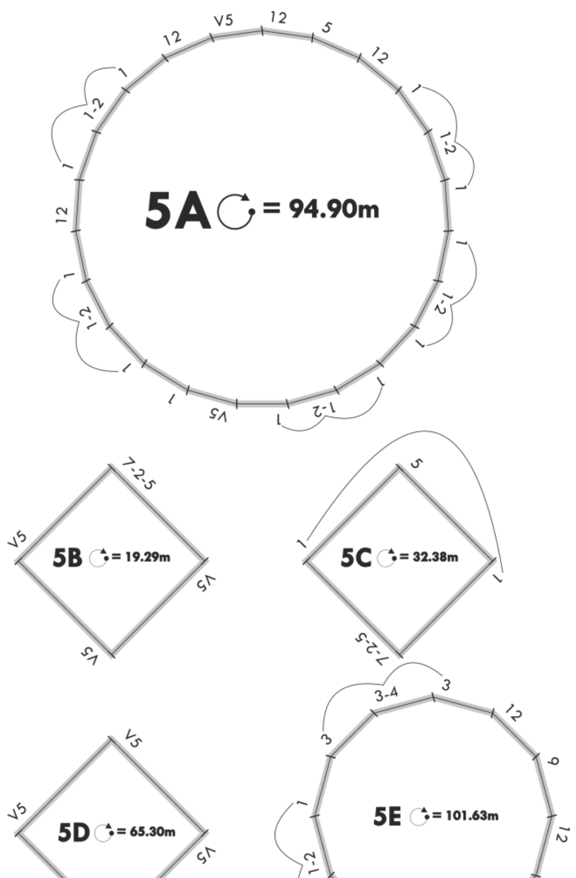

Fig. 9.31: Clock diagrams for 5A-5E in the 1550s time-slice (see Fig. 9.27)

By doing this, it will also be demonstrated how studies into readily comprehensive subsections from a given data selection can be undertaken. Automatically this approach moves the interpretive value of this diachronic comparison to an *arbitrary* level in the aggregative dimension. That is to say that by making a selection on the basis of a measured diachronic observation, it cannot be claimed that this aggregate necessarily has socio-spatial significance as a unit to emplaced lived experience of the inhabitants. Vice versa, neither is the contrary certain. Instead it can be suggested here that the extended street space along the bridge is considered as far as MM and OS1872 are concerned, which may well have made sense to many. The socio-spatial coherence of this entirety is superficially less convincing for 1550s, although the arguably 'added' area designated by 5E still forms a logical continuation with regards to the precinct of St. Mary's Abbey accessible by the V5-3 boundary in the western extremity of **Fig. 9.27**.

Aggregating the subdivision in each time-slice into a single subdivision implies that the respective clock diagrams can be aggregated into a single one for each time-slice. For the reasons stipulated above, in the case of MM 5C_alt shall be used for this purpose to increase historical continuity, geographically speaking. In addition, to not over-represent the street direction choice in 1550s in comparison to MM and OS1872, the latter aggregations include the virtual extensions of the Type 5s to the west. Finally, as detail on distinctions in natural features is limited for OS1872 and 1550s, the two Type 12 subdivisions under the bridge (river flow and riverbank) in MM are amalgamated.

Aggregation of clock diagrams means one should meticulously subtract the virtual boundaries currently separating the discrete Type 5 subdivisions, taking into account any duplication, but also add virtuals appropriately to include the Type 5s meeting the new aggregate subdivision by removing the crossroads, to recalculate the total circumscription length.[131] Furthermore, care should be taken that the final order of the topological segments reflects the situation of the BLT map. The results of these aggregations can be seen in **Figs. 9.32-9.34**.

The effect of the aggregated clock diagrams is that we have an immediate overview of the boundary differentiation for the entirety of each historical situation. The

[131] The length of the circumscription symbolised by the clock diagrams' polygons can normally be retrieved in the GIS environment, as the BLT identification exists as a single data feature. When aggregating this is no longer the case, as these larger circumscriptions have never been separately mapped.

respective number of topological segments (1550s: 40; OS1872: 39; MM: 49) shows much less difference between the 16th and 19th century, despite the dramatic morphological changes. At the same time, and historically expected, from the 19th to the 21st century we recognise an intensification of differentiation. More importantly, the aggregate clock diagrams assist us in producing relative counts of topological segment diversity and per discrete connected space and whether these are readily accessible (i.e. does the space feature a virtual boundary or have an entrance as (part of) the boundary interface with the aggregate subdivision). The diagrammatic representation of these statistics is shown in **Figs. 9.35** and **9.36**.

From the **Fig. 9.35** it transpires that the 1550s urban built environment, by a small margin, materially presents the socio-spatially most diverse situation, while OS1872 features the least diversity. As originally suspected from **Fig. 9.27**, the situation surrounding the city gate in 1550s results in a greater choice of directions in which to move (Type 5s). The intensification of the role played by buildings in MM is clear by the distinct rise in frequency of Types 1 and 1-2, while at the same time the number of roads sees a small decline. Both these observations are reconfirmed when corrected for the number of connected discrete spaces in **Fig. 9.36**. Another important insight becoming clear is that not-man-made boundaries (Type 12) still play dominant role in 1550s, although manipulation of these natural features was possible as testified by the encroachment onto the river of buildings along the bridge (see also Keene 1985). This may indicate that incorporating ‘natural’ boundaries within the built environment might have enabled a greater contribution to resources or facilities needed for everyday inhabitation. Furthermore, it suggests that the pressure to develop additional occupiable surfaces to maximise interactive opportunities must have been low enough to retain these boundaries. Considering that Winchester as a city had been in decline (Keene 1985), this is a reification of the social developmental effects.

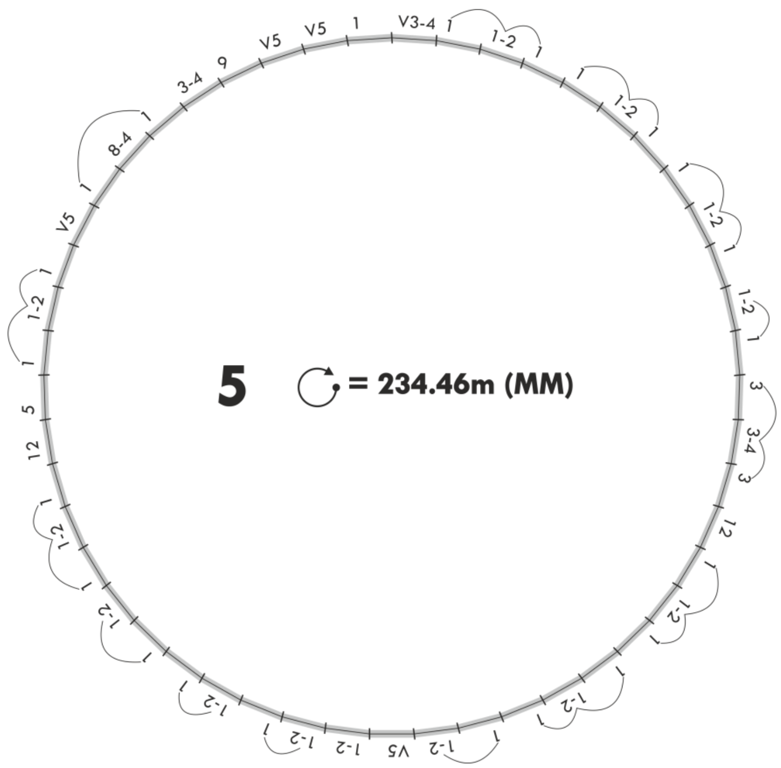

Fig. 9.32: Aggregate clock diagram for the MM time-slice

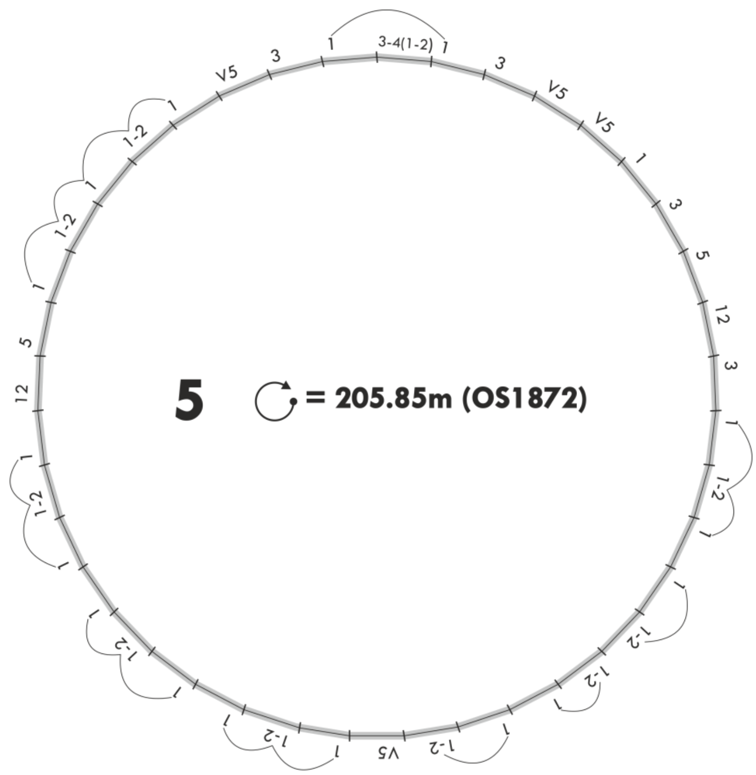

Fig. 9.33: Aggregate clock diagram for the OS1872 time-slice

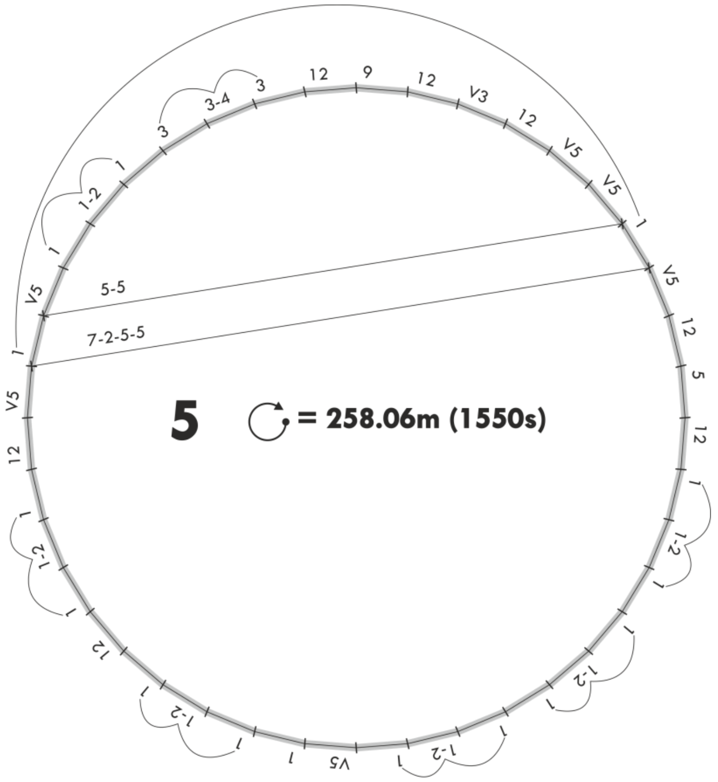

Fig. 9.34: Aggregate clock diagram for the 1550s time-slice
The two diagonals that ‘slice’ the polygon (Types 5-5 and 7-2-5-5) represent the gate house, which must be crossed in order to reach the areas beyond, but the boundaries crossed do not form part of the circumscription of the aggregate subdivision.

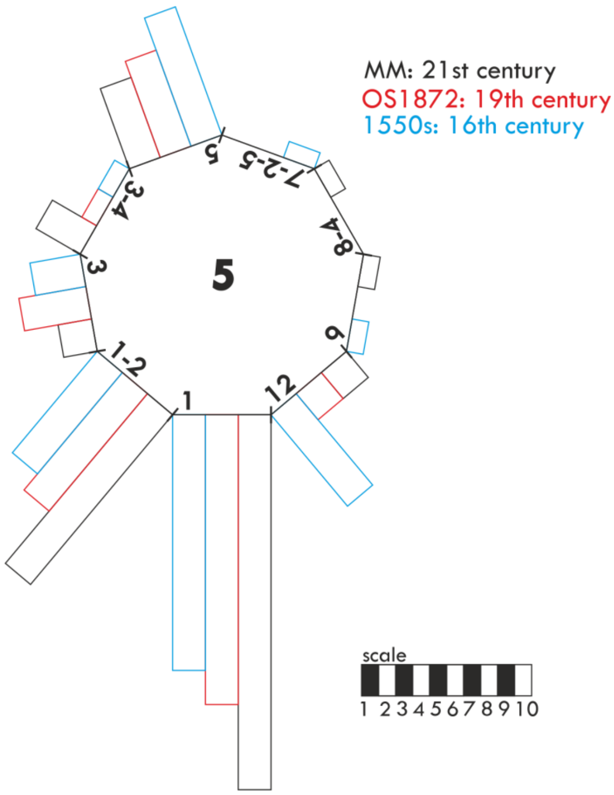

Fig. 9.35: Frequency clock diagram for the diachronic diversity of topological segments
This frequency clock diagram displays the diversity of topological segments of the aggregated Type 5s across all three time-slices. The unique 1550s 7-2-5 segment originates from the city gate, while 1550s also features an additional 5 (cf. **Fig. 9.34**).

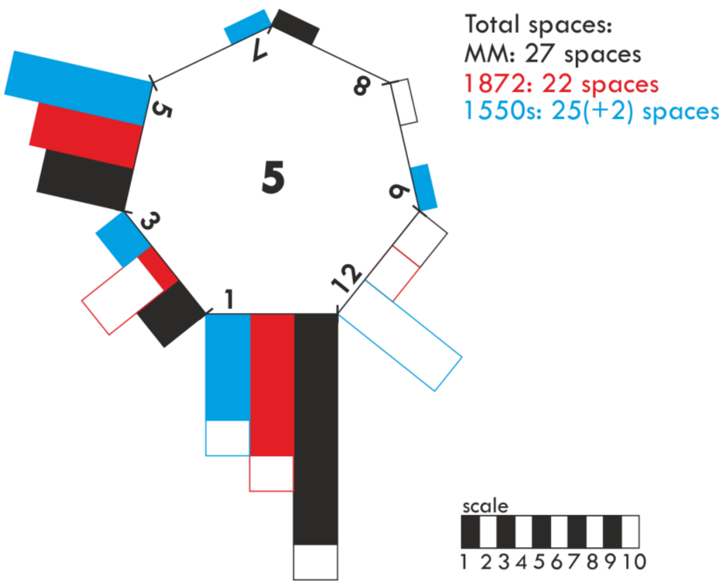

Fig. 9.36: Frequency clock diagram for the diachronic diversity of connected discrete spaces
This frequency clock diagram displays the number of connected discrete spaces, with the solid coloured columns representing the proportion of readily accessible spaces. The two additional spaces in 1550s result from the hierarchically distinct space of the walled city (Type 7) and the street space under the gate itself.

Although perhaps not as clear as by taking into account the whole section of the MM BLT map in **Fig. 9.25**, the number of associative boundaries (Type 3s) historically shows an upward trend. While **Fig. 9.36** shows that the number of spaces resulting from associative boundaries shows a decline, the number of times one gains access to dominants through them rises, thus demonstrating their increasing socio-spatial importance in daily life. Similarly there is a sharper rise in the proportion of buildings accessible directly from the street between OS1872 and MM than between 1550s and OS1872. While the hierarchically enclosing effect of Type 7 disappears after 1550s, not to return, by having used 5C_alt (see **Figs. 9.25** and **9.29**) we can recognise the disappearance of a Type 9 operation in the 19th century, which reappears in that geographical vicinity in the 21st century. Whether this is suggestive of a rhythmic developmental regularity (see **Chapter 8**) could only be revealed by studying a large number of similar situations across time. Lastly, it is easily overlooked that actually the bridge, river, and street spaces, as well as their general pattern of relating to buildings, across all time-slices are cogent examples of stability in development over time and within their modifications have shown more resilience than transformation. Both change and stability are afforded by the material and socio-spatial characteristics of boundaries in the process of inhabitation.

Taking a broad comparative perspective

Adding some final remarks on the historical progression of Winchester in comparison to the Chunchucmil situation — against the background that British urbanism would usually be considered a high-density form of urbanism and Maya urbanism a low-density form of urbanism — the techniques in this chapter now offer an initial means for quantification of what this opposition means socio-spatially. In addition to the general statistical approach opening this chapter, **Table 9.4** repeats the three most relevant quantified formal descriptive measures of **Tables 9.2** and **9.3** on Chunchucmil to include the diachronic test case on Winchester.

Frequency of boundary differentiation over length in metres	**Aggregate clock**	**All segments**	**Corrected for spaces**	**Entrance corrected per space**
	1550s	6.45	10.32 (9.56)	32.26 (28.67)
	OS1872	5.28	9.36	22.87
	MM	4.79	8.68	13.79
	Clock number	**All segments**	**Corrected for spaces**	**Entrance corrected per space**
	9A	34.3	47.4	805.7
	9B	16.2	21	94.6
	9C	17.8	23.7	131.9
	6	11.3	19.2	48
	5A	18.6		
	5Ba	30.1		
	5Bb	17.5		
	5C	24.66		
	5D	33.58		

Table 9.4: Boundary differentiations along the length of Type 5s in Winchester diachronically put against relevant values in Chunchucmil

This table contains the average distances between boundary differentiations along the length of the selected BLT circumscriptions in Winchester diachronically (relevant values from **Tables 9.2** and **9.3** added). The values in brackets include the walled enclosure (Type 7) and the gate's street space in the first instance, and only the gate as an entrance in the second. (Although the same phrase as in **Table 9.3** is used, there are no multiple entrances for any single discrete space in this data selection.)

One should bear in mind that no entrances come out onto Type 5 operations in Chunchucmil, thus the last row in **Table 9.4** has perhaps no valid counterpart in the entrances corrected per connected discrete space along the Type 9 and 5 operations in **Table 9.3**. Yet on the lower end of Chunchucmil (48 against 32.26 or 28.67) the contrast is proportionally fairly similar to the differentiation of all topological segments and connected spaces over the boundary length (11.3 against 6.45 and 19.2 against 10.32 or 9.56 respectively). These measured contrasts only increase as Winchester develops over time and are massive when taking Chunchucmil's maxima (34.3; 47.4; 805.7 respective to the measures in **Table 9.4**). Diachronically it is also shown that while connected discrete spaces take a slight fall between the 16th and 19th century, the intensity of connected spaces remains virtually the same, while the intensity in terms of soliciting access or coming out onto the Type 5s does rise. This last point was not that apparent from **Fig. 9.36** earlier.

At the same time it can be noted that the constitution of inner Type 5 operated subdivisions in Winchester is socio-spatially more diverse (as well as more intense), involving a variety of five (Chunchucmil Type 5s taken together, **Figs. 9.11** and **9.20**) to a maximum of nine different topological segments (in 1550s aggregate). However, if we compare Type 5s in Winchester as circulation spaces to Type 9s in Chunchucmil as an essential component of circulation space, the socio-spatial diversity is greater in Chunchucmil with thirteen against nine different topological segments. To further advance such a discussion it would be necessary to compile all circulation spaces and/or those directing for access to specific destinations and not only regard the number of differences but also the nature of these. Such a study could potentially explain the nature of the differences in interactive opportunities seen from a city's most readily (and logically most often) traversed spaces during inhabitation.

It is readily acknowledged that the analytical examples visualised and discussed in the above are both interpretively limited, considering the strong restrictions on the data selection, and most definitely not exhaustive. In contrast to many of the analytical measures discussed in **Chapter 8** which would require some form of geocomputation, this chapter has shown that a slimmed down and visually more intuitive version of various analytical variables is immediately within our grasp once BLT mapping has been carried out. Few insights have been completely new or beyond expectation. The interpretive dimension of unequivocal interest is that all of these hypothesising insights can immediately be brought into a *comparative* perspective internally and externally, which increases our understanding of the *nature* of the social opportunities offered by urban built environments to their inhabitants on the low interpretive level (**Chapter 1**) of the emplaced lived experience (**Chapter 3**).

As argued in **Chapter 2** the explorations do not necessarily conclude, but merely hypothesise. The validity of the insights reached is determined by their practical adequacy in terms of empirical persistence and whether they are causally sound in constitutive processes. Laterally, it has been reassuring to see several instances of in which analysing Winchester's material-spatial composition reproduces, confirms or suggests things we know from historical research or would traditionally expect to be the case, e.g. in terms of diachronic development processes. On this basis, arguments formulated about the social life in the urban landscape of Chunchucmil can assume greater purchase.

The sheer number of analytical and interpretive opportunities created in the selective and preliminary explorations above, whether pushing the boundaries of knowledge, socio-spatially supporting existing hypotheses, or insights derived from other data, show great promise for more extensive future research, especially building a growing body of case studies. In combination with innovative efforts to make more of the analytical measures suggested in **Chapter 8** fully operational, which can also strongly increase the data selection under scrutiny, it can be securely asserted that a new field of interpretive knowledge has been made feasible by BLT mapping and that applied research in the longer term will grow our critical understanding and appreciation of the patterns of urban life and development. Furthermore, linking up with alternative datasets and other disciplinary research will allow the metaconcepts and underlabouring social science of BLT mapping go beyond speculations on what actually happened in the spatial complex that occurred, conjuring up a fuller image of the afforded processes and affective experience caused by the events of urban inhabitation.

CONCLUDING STATEMENTS

Current results

In this thesis I set out to enable the comparative social study of the material and spatial characteristics of the urban built environment so that significant contributions can be made to improve our knowledge of urbanisation and urban life as a human process of inhabitation. In addressing this overarching concern the research questions guiding this work required the development of much more than just an applicable methodology. As a result this research has produced several major outcomes, which could serve a number of disciplines in different ways, besides those arguably associated with the interdisciplinary scope of deep historical and cross-cultural comparative urban studies.

Initially I developed my own working definition of the city centred on urban life, with structural reference to its physical manifestation. This process oriented, and social practice based, theoretical position overcomes the limitations of comparative urban work fixed in predetermined categorisations. In addition, it was determined that a predominantly low-level interpretive approach ensures the comparative validity of acquiring insights on society-space relations from empirical information without resorting to socio-culturally and historically particular contexts. Throughout this research, process based reasoning has constructed a basis on which the urban built environment could serve as a comparative social scientific object of research and low-level interpretation has been both retained and successfully advanced.

By identifying the strengths of critical realism in allowing one to make structural connections between the conceptual and empirical sides of the research process, which is central to the efforts here to contribute a frame of reference for comparative urbanism to guide a social study of physical characteristics, some contributions to conducting science in a critical realist fashion itself have been made. In concordance with Wallace (2011), I also argue that theorising along critical realist lines is capable of breaching the impasse reached in ongoing debates on materiality and of properly informing and guiding empirical investigations. Placing the built environment as an ontological category within ‘the material’ opens new directions to conduct research on it. The specific perspective taken here on the inhabited (urban) built environment is only one example. The relevance of finding a way in which critical realist thought can engage directly with data on the material record stretches beyond archaeology and could also advance the material turn and critical realism debates in human and urban geography.

The overarching process which this thesis presents could therefore be of support to others seeking to conduct social scientific research on the basis of physical evidence. The pillars of human geographical adaptations of critical realism, including emergent entities, immanent critique, conditional statements, causal powers, contingency and necessity, the importance of (conceptual) ontology, and iterative abstraction have all held their own in the constitutive theoretical framework, the conceptual series and eventual ontology in **Chapters 3-5**. Subsequently, the chapters covering operationalisation, analyses, and test case applications in the quantitative and computational realm maintained a solid link to critical realism’s practical adequacy and multiple methods, and eventually the hypothetical nature of interpretations bound by necessary conditions and causal contingencies contained in the ontological concepts used. The proof of the pudding is in the eating. This thesis demonstrates that critical realism can be adapted to ensure that its process of methodological development and application is appropriate for comparative social research on the empirical data on urban form. Through its particular formulation, it can also claim a spot in the spectrum of empirical urban theories as defined by Smith (2011a).

It could be concluded from the theoretical framework which this research has used to define its particular premise of the inhabited urban built environment, that the material presence of boundaries, as sites of difference or affording differentiation, forms the constitutive element in which the socio-spatial significance (to inhabitation) of the built environment is captured. Therefore interpretation is restricted to the ways in which boundaries afford and affect interaction opportunities (including physical transformation) and thus how these are spatially dependent. This is given further specification by determining the levels or contexts (dimensional, locational, and aggregative) in which socio-spatial significance is incorporated in the iteratively abstracted conceptual ontology of Boundary Line Types (BLTs). The need to formulate an ontology of analytical units which are at once ideational and empirical also required a much more profound understanding of the information potentially comprised in spatial data. The philosophical idea of fiat and bona fide boundaries (Smith & Varzi 1997, 2000) proved itself a useful structure to think with. While in the process of iterative abstraction and the eventual operationalisation the current BLT ontology has proved practically adequate, by its very nature it is open to development through iterative relations with empirical findings. Furthermore, researchers pursuing a disparate (social interpretive) interest in studying the material-spatial characteristics of the boundaries (edges or interfaces) composing the built environment, should be mindful that this research can only vouch for this ontology as causally connected to the perspective taken. Combinations with other information sources and associated interpretations remain correlative on the current basis.

Despite the inevitable limitations both in what is conveyed by datasets and our knowledge of these datasets, in addition to the divergent nature of legacy datasets produced for different reasons and purposes (i.e. archaeological survey, historical documents, historical reconstructions, contemporary maps), it has been demonstrated that in general the ontological conceptualisations (BLTs) can be operationalised in all such contexts, thus maximising comparative potential. While data of all origins need 'rules of thumb' to complement knowledge and fill in insupportable data gaps (for which this thesis currently provides extensive guidance) there are varying degrees of success to report. Perhaps unsurprising for an approach connecting spatial configuration and composition with material properties, this research shows that when working with historically reconstructed maps not primarily concerned with the physical topography of the city, greater conjectures with higher uncertainty cannot be avoided. Good quality archaeological surveys, in contrast, perform naturally better despite the inevitable gaps in its fragmented data. This insight also suggests that if historical reconstructions would directly incorporate references to physical characteristics and structurally conform to archaeological evidence this could provide improvements to resolve instances of grave uncertainty.

The comparative potential of the BLT mapping methodology makes it in its particular interpretive endeavour significantly broader than existing methods and research practice, notably urban historical GIS approaches, urban morphology, and (urban) space syntax. Nonetheless, data acquisition, practical research techniques and terminology, and analytical pointers and principles have benefitted greatly from these research methods. On one level, the methodology of BLT mapping establishes a path for adaptive integration of extant methods, but on another it must be emphasised that it pursues a distinct and complementary interpretive and analytical agenda. Aligned with its distinct objectives, this thesis has reasoned through a number of analytical measures, which are able to directly relate and comment on the levels of socio-spatial significance in synchronic and diachronic applications. Suggestions have been made on the (computational) design of such quantitative spatial analyses, establishing how these could be used to exploratory interpretive ends.

Foundational work on geocomputational programming on what could become an extensive suite of tools in ArcGIS was sourced as part of this project, based on specifications grounded in its theoretical treatise. These tools showed promise despite their current limited applicability. The visualisation tool helping to automatically generate BLT maps sidesteps the ArcGIS proprietary visual functionalities to reveal concealed layers of features in the GIS. These BLT maps directly facilitate the reading of the data and enable the flexible production of, and visualisation in, the purposively developed 'clock diagrams'. These diagrams are able to extract both quantitative patterns and more intuitive or interpretive inspections of the intricacies of the data structure. Another tool automatically disaggregates the BLT data into the smallest socio-spatially meaningful elements as analytical units (topological segments) derived from BLT identifications themselves. This disaggregation offers an immediate overarching view of the socio-spatial signature or ontology intrinsic to the city as an inhabited urban built environment and adhering to the working definition initially proffered. As such this research has produced an example of qualitative analytical use of vector GIS technology.

Although within the confines of this thesis the interpretive findings on the test cases have remained very limited, they are indicative of how worthwhile directions for specified thematic interpretation are supported. With regards to Winchester it could be proven that BLT mapping directly reflects the stage of urban development in the Victorian era and could make a strong case for the general functioning and social position of the eastern city gate. Diachronically the general processes of development, such as pressure on included natural features, and intensification of architecturally bounded occupation and associated changes in plots, started to reveal themselves even on a tiny scale. Analysis of BLT data also produced the first indication of the actual differences between inhabiting low-density and high-density urban form, enabling the assessment of relative complexity and diversity in interaction opportunities. In comparison with Maya Chunchucmil the first findings on Winchester appear to confirm what we would expect from current lived experience and knowledge on western (or globalised) urban form, thus further strengthening the case for a proof of concept. The preliminary findings on Chunchucmil include a much improved appreciation of circulation space and the differences in traversability opportunities afforded by the specific BLT circumscribed subdivisions involved, a specification of the socio-spatial change involved in changing one's location along origin-destination paths, and initial indications for the great stake of shared plots in making up the built environment and the rather more specific relative socio-functional position of formal plaza groups.

Future research

Both in the above and throughout the chapters various suggestions and indications for future research have been made. The current section collates and outlines these opportunities concisely. In virtually all instances, the methodological nature of this thesis is aimed at enabling new and alternative ways of knowledge production, both as an overarching research process and as a specific comparative social methodology for urban studies. The early successes of the approach presented in this thesis should invest interested researchers with the confidence to carry on further work following the same process. Accepting the specific social interpretive focus on the inhabited urban built environment pursued by this research, the first opportunity for future research consists of developing full-fledged case studies from the test cases presented here, Chunchucmil and Winchester, and to keep adding further examples and further variety to the urban history and traditions covered between these two. In this way ever stronger cases can be made for the specific contributions made by BLT mapping to comparative research on urbanisation and urban life, and with extensive coverage the relevance of these findings (contrasting differences, similarities and regularities) to understanding both past and contemporary urban societies and building cultures will increase. It should be appreciated that the processes involved may be laborious and the uptake of new methods and technology can be slow, therefore such general contributions will be part of a long term development.

More immediately, within the suggested case studies or within further limited test cases and data selection, thematically focused interpretive studies can be undertaken. Most immediately these would include the socio-spatial composition and relative position of architectural complexes, the patterns and relations making up neighbourhood effects and other aggregates, full studies of circulation space and the qualitative differences in the kinds and associations of urban open space. Diachronically one could concentrate on the socio-spatial development of how all of such aspects of urban form function and adapt and show rhythms in the changes they afford. Such thematic foci could further be reinforced by structurally linking and engaging with alternative information sources available on the same city. In this way the functional typologies of architecture, locations of resources, activity areas, places of production, marketing, and consumption, but also the labour investment in the material construction of a city, architectural styles, defensibility, and symbolic communication could be operationalised by investing such information in the BLT GIS data structure. The same applies to e.g. more specifically urban morphological variables, including metric measurements, urban fabric, and morphological development zones. The example of combining accessible area sizes with clock diagrams demonstrated some of these to be within immediate grasp.

Within this research I have suggested chances for future research to develop, intervene in, or deviate from the current propositions. As mentioned above, it is the nature of iterative abstraction that empirical findings could require future revisions of the ontological concepts. But besides such inevitable development, arbitrary preference for another level of detail or a disparate interpretive research interest would demand the complete reformulation of the BLT ontology, even though one may retain the boundary conceptualisation and theoretical framework. This is because it cannot be argued that the same ontological concepts would necessarily (causally) support inference towards theoretically unrelated hypotheses. Nonetheless, when interpretive correlations are found or if combinations with complementary extant methods reveal specific correlations, such conceptual and empirical serendipity could lead to new questions guiding further research efforts to explain why this may be the case. Regardless of supplementary lines of research, the limitations of BLT mapping include that it makes no predictions on what actually occurred and cannot explain why things occur. Because BLT mapping and analysis form a rudimentary level of interpretation, other methodologies with suitable credentials could be critically reviewed with the aim of forging argumentative synergy with BLT mapping’s basis, which entails the affordances and affective influence of the interactive framing that did occur in the development of a built environment and how these phenomena are related.

Finally, the preceding correlative combinations could form the basis for integrative adaptations of several methodologies, such as urban morphology and space syntax. It has been argued how the BLT GIS data structure maintains the detail required for these kinds of studies and how GIS is surfacing as the computational interface on which initial attempts have been carried out to operationalise extant methodologies and to some extent start such integration. While BLT mapping cannot claim that it integrates the merits of extant methods in itself, its purpose is positioned as complementary to these and its data requirements will in essence collaborate with them instead of further dispersing the field. Together with the hypothetical analytical measures reasoned through and explicated in principle throughout **Chapter 8**, further geocomputational development to create a comprehensive BLT toolkit can complement those measures already existing for space syntactic analysis and morphological variables in GIS, such as density. Simultaneously, for BLT mapping the computational work on developing appropriate spatial analytical tools is a future research challenge in its own right too.

Eventually it is expected that continued research using BLT mapping and derivative methodologies will make a significant contribution to our understanding and appreciation of the processes of urbanisation and urban life in all its protean possibilities. This will include explication of the developmental processes of materialising the environment, the socio-spatial patterns of coherence on local and aggregative scales, as well as an appreciation of the interaction opportunities available at each location and between locations across a full urban built environment, and the social stability and changeable pressures implied by such material-spatial affordances and affects. Knowledge about the socio-spatial functioning of life within any built-up urban space, the regularities and differences, the successes and defects, may then go on to inform and empower interventions, modelling and planning in urban design, based on proper socio-spatial theoretical principles and supported by solid evidence-based exemplification. Ultimately, all research sharing the concerns in which this thesis is embedded will work towards uncovering and reifying the original blueprint of human inhabitation of the world.

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