

## **Building a timeline, developing a narrative: visualising fringe belt formation alongside street network development**

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**Abstract.** *This project was developed as an attempt to assess the relationship between different morphogenetic processes, in particular, those of fringe belt formation as described by M.R.G. Conzen (1960) and Whitehand (2001), and of centrality and compactness as described by Hillier (1999; 2002). Different approaches focus on different elements of the city has made it difficult to establish exactly how these processes interact or whether they are simply different facets of development reflecting wider socio-economic factors. To address this issue, a visual, chronological timeline of Limassol's development was constructed along with a narrative of the socio-economic context of its development. The complexity of cities, however, makes static visualisations across time difficult to read and assess alongside textual narratives. We therefore took the step of developing an animation of land use and configurational analyses of Limassol, in order bring to life the diachronic analysis of the city and shed light on its generative mechanisms. The video presented here shows that the relationship between the processes mentioned above is much stronger and more complex than previously thought. This related paper explores in more detail the links between fringe belt formation as a cyclical process of peripheral development and centrality as a recurring process of minimisation of gains in distance. The project's outcomes clearly show that composite methods of visualisations are an analytical opportunity still little exploited within urban morphology.*

*Keywords: Fringe belts, street network, urban history, visualisation, Limassol*

### **Introduction: background to the project**

The development of cities is influenced by many factors, the time of their foundation, their early development as centres of religious institutions, government administration, locations for trade and cultural exchange. Their geographical location often has an impact on their role within a specific region and their topography also plays a part in the way they develop. Historical events impact on their expansion or contraction and on their development or redevelopment, while formal planning by government authorities following industrialisation naturally plays a leading role, along with market demands and pressure from the real estate industry.

Cities have a history, which is written into their urban form and built fabric; different periods manifest themselves in street patterns, architectural styles and the functional distribution of uses throughout the city. As a period follows another so the cityscape changes and the contemporary city ultimately is an accumulated historical record of all the factors that have shaped and influenced its development, however “it is an incomplete and confused record since the features created in one period are subjected to change in another in varying degree” (Conzen 1960, p.6). In most cases the existing fabric of cities tends to be adapted rather than replaced during successive

courses of redevelopment. It is only in extreme cases following natural or man-made disasters or through specific urban interventions such as slum clearances that substantial replacement of the existing fabric is likely to occur, and this is likely to occur only in large cities. For this reason, as M.R.G Conzen (1960) points out, the most changeable element of cities is land use, which tends to respond quickly even to small or specific changes such as the introduction of a new street or the implementation of a transport link. On the other hand, the street is the most resistant element of cities as new roads in existing areas or significant changes affecting the street network are limited.

Diachronic analysis of cities aims to study the human form of settlements and the process of their formation and transformation. However, it remains a challenging area for scholars in different fields, as the complexity of cities makes them particularly hard to analyse, especially across time.

Furthermore, assessing how cities have developed requires both accurate cartographic records as well as historical and current sources of information on their demographics, their history and their land uses. Many historical records and data, even within a short time span, are not easily comparable to current ones and tend to require either processing or summarisation for comparison. At the same time differences in the quality of cartographic records and the points of interest and land uses they report means that analytical tools able to capture specific properties of cities regardless of the detail of information available, are needed in order to assess changes in the built form, identify what processes enable such changes and relate these to the ways in which cities function.

Despite these barriers, the scholarship in the field of urban morphology is vast and has led to the identification of certain processes according to which cities evolve. This has in turn led to new and refined theories of the city and potential 'rules' of development applicable to all cities, as well as universal and individual characteristics which define the nature of cities.

Different methodologies have been developed to approach the analysis of the evolution of cities, but have often been applied

in isolation and have led to the emergence of separate schools of thought. The main approaches and their related schools of thought are: 1) the historical-geographical approach of the British school of town plan analysis initiated by M. R. G. Conzen in the 1960s; 2) the process typological approach of the Italian school based on the work of S. Muratori in the 1940s; 3) the configurational approach developed by the space syntax community following the work of Hillier & Hanson (1984); and 4) the spatial analytical approach which is applied through a variety of methods by different scholars, but is mostly associated with the work of the Centre for Advanced Spatial Analysis (CASA).

This paper focuses on certain developmental processes identified through the application of the historical-geographical approach and the configurational approach, namely the processes of fringe belt development and those of centrality and compactness.

### **The process of fringe-belt development**

The process of fringe-belt formation involves the establishment of certain land uses at the urban fringe during periods when the built-up area is stable or only growing at a slow pace. Initially, fringe belts include large open areas, public utilities and open land attached to institutions (Whitehand 2007). Following this occurs a filling-in of gaps during periods of high-density development, followed by further expansion. The process of fringe-belt development is characterised by a series of subsequent phases: a fixation phase of initial establishment, followed by an expansion phase, and then a consolidation phase (Conzen 1960). Fringe belts are also subject to a number of transformations, known as reduction, absorption and translation (Conzen 2004).

Whitehand (1977) analysed the relationship between building construction cycles and fringe belts; his findings showed a link between the urban economy and the various phases of fringe belt formation and residential growth. According to these findings and later research it is during economic slumps that institutional and private development which require large spaces accumulate at the urban fringe,

while during economic booms residential building extends into the new urban periphery (Whitehand 2001). How the process of fringe belt formation and densification by residential development occurs either as concentric belts or as radial routes is exemplified in figure 1 – the two models are not exclusive of each other and in real-life cases they can overlap.

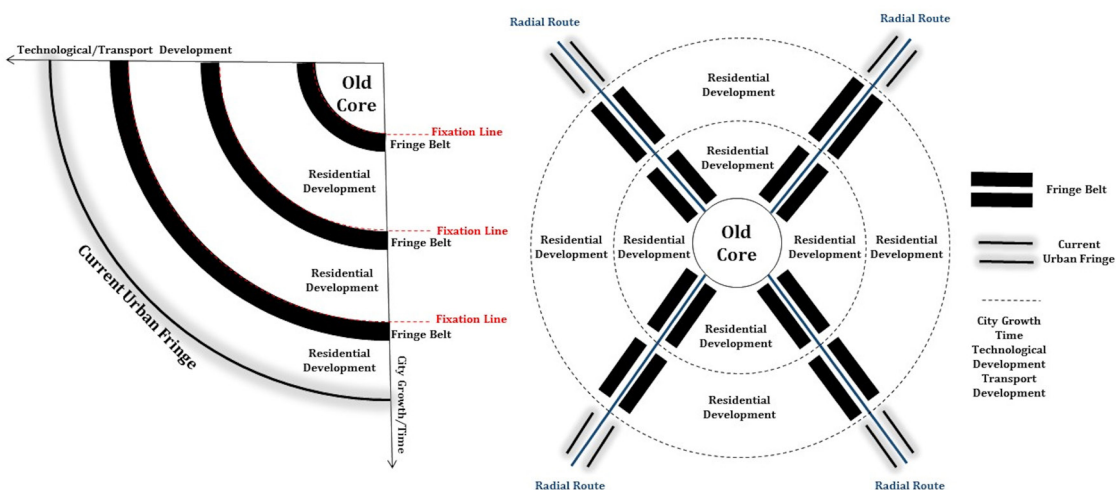
**The processes of centrality and compactness**

The configurational approach identified certain invariants and differences across cities: they share similar global structures in the shape of a deformed wheel, but highly different localised spaces, in particular residential areas, which reveal different forms from city to city, country to country and even more so, from culture to culture. Hillier (2002) theorised that these similarities and differences are driven by two kinds of social forces, the micro-economic and the socio-cultural forces respectively.

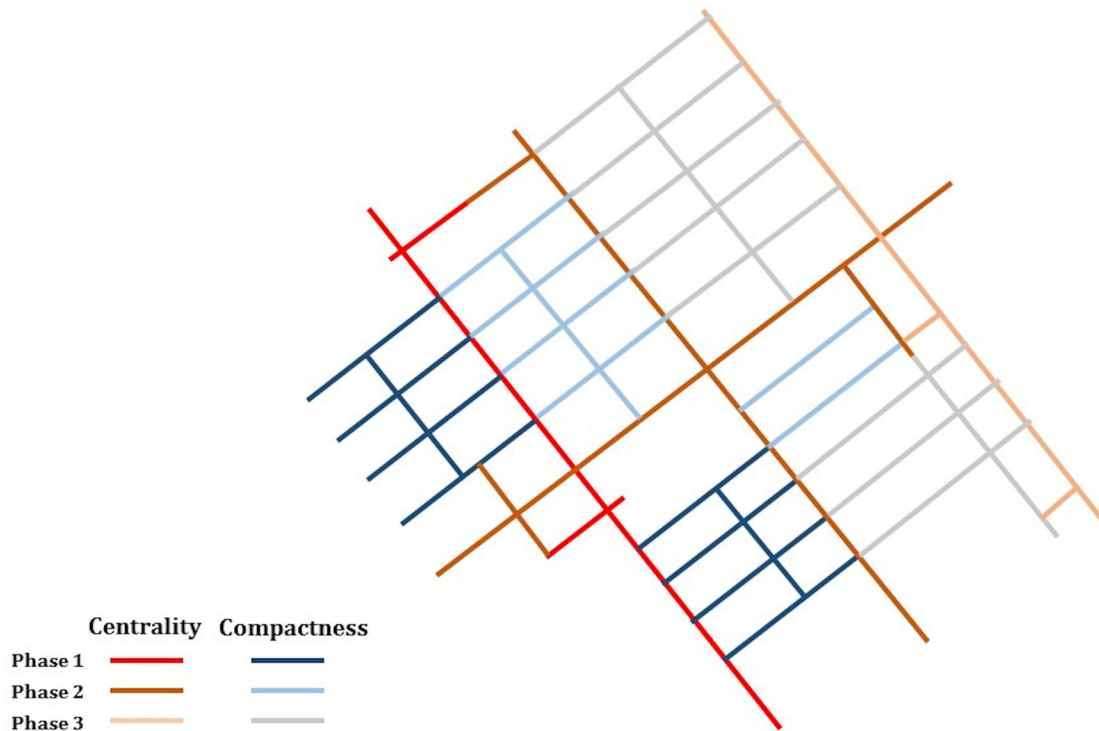
These invariants and differences are related to the processes of centrality and compactness. Hillier (2002) demonstrated that centrality has a powerful impact on the generative process of cities, to the extent that he defined it as a generative law, which states that “an object placed centrally in a space will increase universal distance<sup>1</sup> more than one placed peripherally” (Hillier 2002, p.17). This has implications for the way cities change when

built elements are added to an urban system as an object placed close to one object and far from another will minimise the increase in universal distance. The opposite is also true: an object placed at equal distance from two other objects will maximise the increase in universal distance. Doing the former will tend to create long and short lines, while doing the latter will tend to create lines of similar length. If creating longer lines, even if this causes the creation of a short line, is beneficial to minimising distance, then it follows that conserving longer lines at the expense of shorter lines when a system changes will also minimise the gain in distance and hence will preserve interaccessibility as a settlement grows. The counterpart to the law of centrality is the law of compactness, which states that “the more compact an object or group of objects... then the less the increase in universal distance in the surrounding space” (Hillier 2002, p.18); this means that a compact object will also minimise gain in universal distance compared to an elongated object of equal area.

Hillier then argues that local interaccessibility operates through the compactness law which is driven by the residential process and socio-cultural factors, while global interaccessibility operates through the centrality law which is driven by settlement growth, the public space process and micro-economic factors. At certain transformative stages of a city a large gain in accessibility values of a locality is followed by



**Figure 1**  
Conzen's fringe belt model as concentric belts (left, adapted from Whitehand, 1994) and as radial belts (right)



**Figure 2**  
Generalised model of the processes of centrality and compactness.

subdivisions in the same areas. This indicates that centrality drives the generative process and precedes the emergence of densification through compactness, articulated in the development of grids in areas surrounding long routes, as well further subdivision of existing grids (Al-Sayed et al. 2012). A generalised model of how the two processes operate over time is shown in figure 2.

### The relationship between processes

The fringe belt concept and the configurational laws have one fundamental difference (their focus on different elements of the city) and one clear commonality (the identification of economic factors as a leading determinant of the development process). The former focuses on buildings and its associated elements (the building, the block and the plot). The latter focuses on the streets and their properties (the street, the routes, the street segments, their connections and so on); something often referred to as the 'space' between the buildings

where the social life of the city occurs. Scholars of both fields would certainly agree that the two forms are inextricably linked; the one would not exist without the other. Research from both fields also provide us with some indication of the relationship between the two, most notably, on the one hand, that fringe belts tend to form along long radial routes or in circular strips; they are also normally defined by a fixation line which may be a road, most often a wide vehicular road. On the other hand, the spatial properties of streets tend to correlate with high levels of specific land uses, in particular the distribution of commercial and service uses. Furthermore, the processes of centrality and compactness are determined by the effect that the form and size of buildings has on the property of universal distance.

What the two approaches have not yet explicitly attempted to do is to clarify the relationship between the two built forms in terms of their morphogenetic role, in particular their respective role in the formation of urban areas through their distinctive phases of growth. Nor attempts have been made at

understanding the relationship between the processes identified, despite the commonalities mentioned above. The aim of this paper is to initiate a debate on possible methods for assessing what the linkages between these processes are and how they interact.

### **Scope of the project**

In recent years a number of studies, initiatives and events, (Kropf 2009; Zhang 2015; Oliveira et al. 2014; Oliveira et al. 2015; Scheer 2016) have explored bridges between the different morphological approaches in order to assess the viability of a common framework and of a multidisciplinary analytical approach. While the needed comparative work on the different schools of thought has been initiated, there are still limited analyses and elaborations of how the approaches are interlinked and how they can be brought together within a comprehensive framework.

Furthermore, the advancement of such comparative and multidisciplinary work is fraught with the difficulty of analysing and understanding urban growth and the human intervention in such growth that has occurred throughout centuries of urbanisations. Attempts to embed the temporal process in theorisations and methodologies for the study of cities' transformations requires an understanding of the structuration of space in time. Such attempts are discussed in theoretical and methodological debates (Baker 2003; Griffiths 2011; Netto 2016) and do exist in empirical studies (Griffiths 2009; Al-Sayed et al. 2012; Charalambous & Geddes 2015), but remain limited and are still not fully developed and exploited.

The idea underlying the project is to move beyond a view of history as a simple contextual factor or a view of ideology as being the lead determinant of form. In doing so, the temporal factor shaping the structuring of form must be deployed dynamically: the attempt is to develop an approach to describe the relationship between spatial, physical and socio-economic factors diachronically. In order to do this, the project first focused on assessing the existence and nature of the

processes of fringe belt formation, centrality and compactness in Limassol through separate historical-geographical and configurational analyses of the city; at the same time a historical review of the city's development was carried out. At a later stage the analyses were layered as individual maps for each point in time for which analysis was carried out and then they were brought together into a single 'timeline' aimed at visualising the relationship between the different processes across time and linking these to social and economic information derived from the historical review of the city. While the timeline provided various benefits for the understanding of the city's development, the linkages between the processes and the socio-economic factors remained static and difficult to read. For this reason, a decision was made to animate the timeline into a video. This paper briefly describes the methods used to develop each analysis and the timeline; it does not discuss the analyses individually or make an argument as to the existence and the nature of each process in the specific case of Limassol: these processes do exist and are discussed elsewhere (Geddes 2017). The paper does, however, present the timeline and discusses how this was used as the basis to construct the animation of Limassol's development. The procedures used for animating the timeline are presented, a portion of the video resulting from this work was shown at the ISUF 2017 conference. The benefits of the output as an analytical tool, a dynamic visualisation as well as a communication medium for urban morphology are discussed in the last section of the paper. The full version of the video will be presented within the context of the Cyprus Network of Urban Morphology (CyNUM)'s seminar series towards the end of 2017 and later made available through its web site ([www.cynum.org](http://www.cynum.org)) and through social media.

### **Methodology**

The methodology used to develop the timeline comprises the creation of two parallel accounts of Limassol's development. On the one hand is a narrative which describes, through historical and archival research of primary and



secondary sources, how the city has grown and changed since the 19th century, when textual records and historical data become relatively substantial, until contemporary times. At the same time, accounts of the actors involved in decision-making for particular sites, the reasoning and forces behind certain planning developments are reported and discussed through conversations with a variety of stakeholders. The full narrative is available elsewhere (Geddes 2017) and a summary of it, including an in-depth discussion is being prepared for publication. On the other hand, is a spatial history of the city, which focuses on systematically analysing the development of the city's street network and its built form at six specific points in time for which cartography is available (1883, 1933, 1960, 1974, 1987 and 2003). The specific methods used for analysis were a configurational analysis through space syntax methods, a land use analysis and a block size analysis – all are described in further details below. This spatial history attempts to build a timeline of the city's development to identify how the sequence of physical events in the growth of the city affects its spatial and physical properties.

### **A narrative of Limassol**

In the context of this study's framework, the meaning of 'narrative' as a research method is taken from Actor-Network Theory (ANT) (Latour 2005), which requires to provide a description where all the actors involved in the process of emergence are accounted for and their actions are outlined. The aim of the narrative is to fully depict a state of affairs by being specific and accurate while capturing the broad-ranging connections between different components. The narrative is developed and written by the researchers themselves. However, here, we are not strictly using ANT methodology to construct a narrative, which would involve the tracing of a network. Instead, we are using a combined approach, typical of more 'classic' social research using narrative as a qualitative method, where the narrative serves the purpose of providing an analytical layer. The narrative itself is still developed

by the researcher, but through the collation, description, interpretation and communication of existing knowledge of the city, through researching primary and secondary sources, including photographic and cartographic material, and press archives, as well as through holding conversations with expert stakeholders.

The historical context within which Limassol developed was investigated through a literature review of secondary sources. Substantial research on Limassol's urban history was compiled by Serghides (2012) in a book which focuses both on the growth of the city and the development of specific areas and architectural landmarks, but in particular the industrial development of the city. The book takes a historical approach to the description of the city's development rather than an analytical one. Primary sources which describe the city included a small number of historical tourist guides produced between the beginning of the 20th century and 1974, and a number of historical travellers' diaries from which the information regarding Limassol was collated by Severis (2006). Some other records regarding the city, such as police reports and newspaper articles were also found in other secondary sources.

Another primary source was newspaper articles from the archives of the Cyprus Press and Information Office (PIO). At present this archive provides a searchable database of about 20% of the material from 38 Greek and English language newspapers dating from 1880 to 2006. The PIO's resource was used to gain further details about Limassol's development timeline, in particular major infrastructure works and large developments. Following a review of the historical cartography and of the land use analysis, the search focused on the major developments in the city; this yielded 15 articles of relevance dated between 1953 and 2000.

Conversations with expert stakeholders had the dual purpose of retrieving information which is lacking in the available documentation, and of collating a variety of different viewpoints on the reasoning behind development and on the actors involved in the planning processes. The conversations, firstly, aimed at clarifying some of the mechanisms of the city's development

and to retrieve the dates of planning and construction of major routes and building projects requiring large land areas. Secondly, they attempted to gauge expert opinions on the value of various projects as well as the reasoning behind them. A total of 6 in-depth conversations, in the form of semi-structured interviews, were held with the experts. Extracts and information from the conversations were not included in the timeline, but were embedded within the general historical narrative.

Whenever possible, information on the dates of planning and construction of specific developments is matched to data on GDP growth, which is available in detail from 1974 to the present day (figure 3). Prior to this date, the relationship between planning decisions and economic circumstances is assessed analytically based on the historical context. This is done in order to gain an overview of how processes of development discussed above relate to their common economic element.

### A spatial history of Limassol

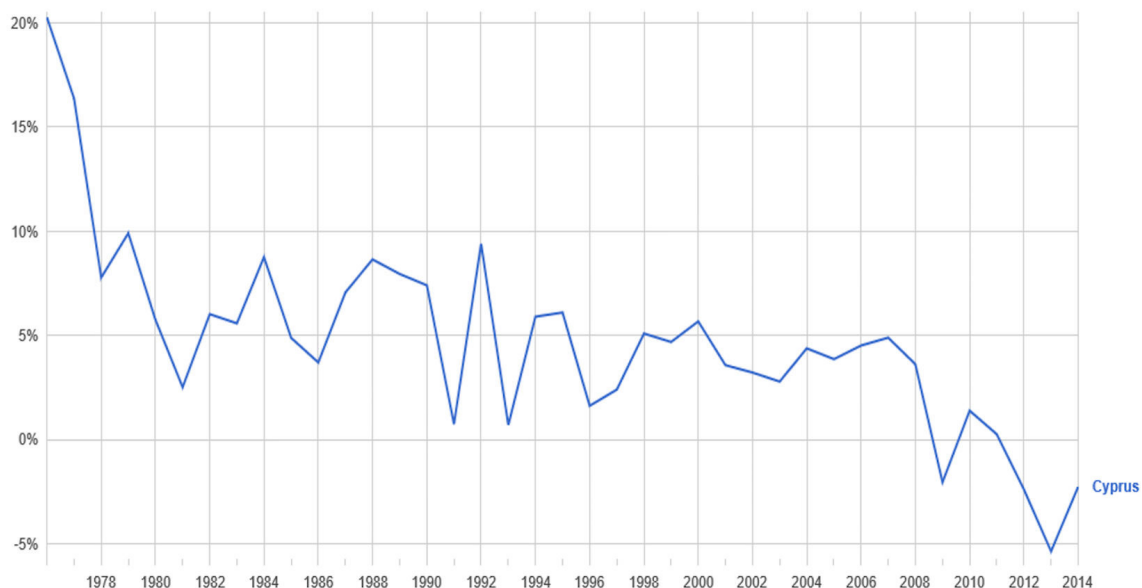
The aim of the spatial history is to reconstruct the key features of the city's growth at specific times in the past, while assessing the

relationship between spatial and locational factors and how this evolves.

The spatial history is composed of three layers of information relating to the material components of the city: an analysis of the spatial properties of the street network, an analysis of a physical property of the built form (block size) and an analysis of a socio-economic property of the built form (land use).

Six spatial models of Limassol were constructed using space syntax methodology<sup>2</sup>. The specific analysis used in this study is angular segment analysis; the measure used is normalised angular choice (NACH), which measures the number of shortest routes going through each segment and allows for comparison between systems of different size. In each individual map in the timeline, the routes which very high NACH levels are highlighted.

Block size maps were automatically constructed from the spatial models; these give us an indication of the city's permeability levels. By performing this analysis diachronically, block size measures also give us an indication of the extent to which and at what rate newer peripheral areas of the city densify. Block size analysis can be combined with land use analysis to inform the identification of different



**Figure 3**  
Cyprus's GDP growth 1976-2014.

fringe belts in the city in cases where maps of plots are not available, and to assess how these relate to the evolution of the street network and to the density of their surrounding areas. Block size per se cannot be used as a tool to identify fringe belts as these are essentially defined by plot sizes, their boundaries and their aggregation as well as by their land uses. However, it can give an indication of the formation of peripheral zones with large blocks in the city – details of the limitations with regards to using a combination of block size and land use analysis to identify fringe belts are given in Geddes (2017).

Layering the analyses aimed at assessing the relationship between the location of large blocks of specific uses and the evolution of the street network. In order to visualise the establishment of specific land uses in peripheral areas, schematic maps of the city were created for each time period. The maps embedded in figure 4 report in simplified form the extent of the built fabric of the city and highlight the individual large blocks whose use is identified in the maps. The large land uses are coloured thematically according to their time period. Such analysis provides us with the information to identify any potential fringe belts and whether these relate to the routes with high NACH.

### Visualising the outputs: timeline and a narrative animation

The material developed through the analyses discussed above was layered in order to develop a visual timeline, which combines the maps resulting from the quantitative analyses with textual information from historical sources. In the timeline, the major routes identified through the space syntax analysis were layered over the land use maps, thus providing the opportunity to assess how potential fringe belts relate to highly accessible routes. At the same time, a linear chronological rule following the sequence of maps reports relevant dates and events, as well as extracts from primary sources. This timeline aids the assessment of the inter-relationship between fringe-belt and configurational processes, thus shedding light on whether they are at play in the emergence of Limassol's urban form, how they interact and how they relate to historical events and other socio-economic factors.

The timeline shown in figure 4 reports a schematic version of all available maps from 1849 to 2003. The key physical features of the city are reported in these maps along with the extent of the high-density built-up area and the peripheral fringe belt uses identifiable in each map. The roads which have very high choice

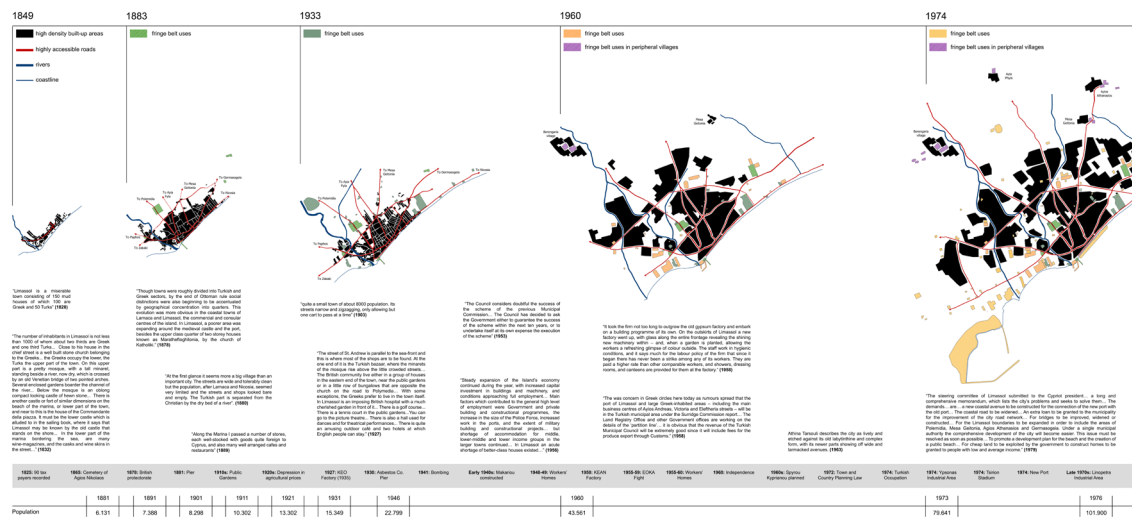


Figure 4  
Timeline of Limassol's development (I)



values, as measured by the configurational analysis, are highlighted in red for every point in time (a high-quality version of the timeline is available from [www.cynum.org/limassol](http://www.cynum.org/limassol)). The maps are presented in chronological order alongside primary sources which describe the city at different times in history. Key historical events, the establishment of very large land uses and significant road infrastructure are also reported chronologically, as is the population growth. The timeline summarises elements of the narrative and of the spatial history of the city by layering all the pieces of information onto one medium. In doing so it is particularly useful not only to relate the formation of fringe belts to specific elements of the road infrastructure, but also to highlight how the accessibility of the street network of the city shifts in relation to the formation of fringe belts and to the processes of densification. The timeline also permits us to easily relate key historical events to the urban form as the temporal aspect unfolds, while being able to perceive the scale, population growth and increased complexity of the city as time goes by.

As a combined visualisation of separate analyses used for this project, the timeline shows to have relational potential for effectively linking how different processes are taking place in the city; as such, though static,

it is a very effective output and thus provides the basis for the development of further, more complex visualisation tools.

In order to develop such tools, an animation of the timeline was created. For this, four actions were undertaken to prepare the material for animation. Firstly, the narrative was split into two separate sections: one including only the primary sources reported in the timeline, the other comprising a summary of the researcher's narrative, including information from various secondary sources and from the conversations with expert stakeholders. Secondly, this latter narrative was rewritten and refocused on the interaction between the processes, historical events and socio-economic factors by highlighting the findings from the various analyses. The description of the city's development was therefore a summary of that originally developed for the analysis in order to meet the requirements of a medium different from that of a research paper. The two sections were then recorded separately. Thirdly, a storyline was developed by the researchers describing in detail how the timeline should unfold in relation to the two separate narrating voices and to the visual appearance of the different elements from each map in the timeline. Finally, the layers of each map presented in the timeline were split according to the storyline and the sequence of elements appearing in the animation.

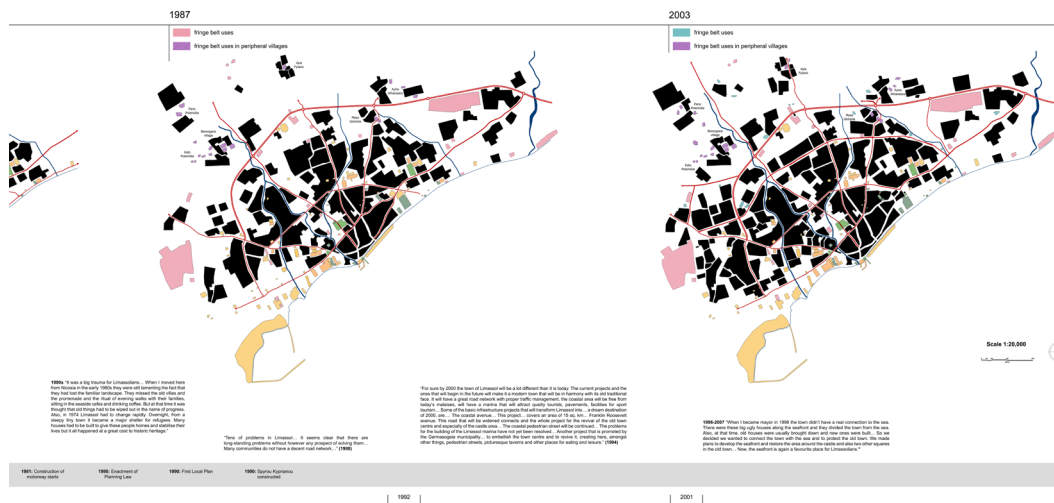


Figure 4  
Timeline of Limassol's development (II)

Ultimately, the researchers worked along a professional animator to produce a video in the format of a mini-documentary narrating and displaying how the built form and the street network of Limassol developed and changed since the middle of the 19th century to the early 21st century.

## Discussion and Conclusion

This paper initiated a reflection on and explored the linkages between the processes of fringe-belt formation and those of centrality and compactness. The project explored avenues to assess the relationship between such processes by firstly carrying out separate analyses to identify the existence and nature of each process in the case study of Limassol and then layering the analyses and linking them to socio-economic factors. Two outputs resulted from the project: a static timeline in the format of a digital and paper drawing, and an animation of the timeline with the addition of a narration explaining the timeline itself in the format of a video.

Looking at the outputs, it is clear that cyclical change and growth are occurring in Limassol through the combination of development of long routes and establishment of fringe belt uses, and densification, with the change occurring repeatedly to spatial properties and to the character of fringe belts.

The main structural changes affecting the urban form of Limassol are the passage from the Ottoman to the British rule, the influx of rural populations during the 1920s, the influx of refugees and the economic slump after 1974, the economic boom of the 1950s, and the economic recovery of the 1980s and 1990s.

The main physical characteristics displayed in Limassol's growth and change are the formation of fringe belts, including two separate and different functional zones (an industrial one in the west and a tourist one in the east), the development of an extremely strong road 'superstructure' with the imposition of a 'fan-shaped' network onto a deformed wheel, and low density of the urban fabric composed of a patchwork of residential areas.

The processes of fringe belt formation and that of centrality seem to be the two key mechanisms shaping the form and character of the city. However, while these are clearly linked to certain historical events and social circumstances, the relationship with economic cycles is not as clear.

The results of the project offer two significant contributions to the field of urban morphology. The first is the identification of the fact that the relationship between the process of fringe-belt formation and that of centrality seems to be very strong and deserves further investigation through other, more empirical methods. The other is an accessible and communicative tool to visualize the results of different urban morphological approaches and to communicate these not just within academia, but also more widely to the planning and design sectors, as well as the general public.

## Notes

1 Universal distance is defined as the average distance of each segment from any other segment in a system, see Hillier (1996, chapter 3) for further details.

2 Further details on all aspects of space syntax can be found through [www.spacesyntax.org](http://www.spacesyntax.org) and in key space syntax publication including Hillier and Hanson (1984) and Hillier (1996), Hillier and Iida (2005) for details of angular analysis, Hillier, Young, and Turner (Hillier et al. 2012) for details of the normalised choice measure.

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