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Beyond the suburban high street cliché - A study of adaptation to change in London's street network: 1880-2013

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This article addresses the question of how the fringes of cities develop spatially at both the local scale of the individual town centre and in relation to the wider urban network. The changing network structure of the street systems of two outer suburban areas of Greater London, Surbiton and South Norwood, are analysed from the 1880s onwards. A temporal reading of the process of urban growth in relation to the historic street network of local centres allows for a nuanced understanding of the way in which cities grow over time. Rather than conceptualising suburban growth as either a seeding of new territories in *tabula rasa* or a 'swallowing-up' of older settlements, this article argues for a measured description of the spatial, social and economic properties of urban grid intensification.

This research uses digitised historical maps, historical and contemporary land-use data together with space syntax analysis in order to identify historical-morphological parameters of change and continuity in London's suburban street network from the 1880s. The analysis demonstrates that over the period of time considered there have been distinct stages in the spatial development of the city's urban fringe. The results show that as London expanded to encircle new territories, the spatial relationships of fringe areas of the city changed markedly as larger scale infrastructure was built and local development intensified, with the effect of reconfiguring the local network of the case study suburbs. However, detailed analysis of the formation of suburban town centres using space syntax also uncovers distinctive and resilient spatial morphologies which have sustained varied modes of land use over time. Drawing on the theory of the urban 'movement economy' and our previous research in this area, the article shows how the complex balance of change and continuity realised in the spatial morphology of the suburban high street can be explained by complex scalar mechanisms of adaptability. We argue that these qualities have helped ensure the resilience of historical suburban centres even in the face of radical social change.

1. Edge city or porous fabric?

London is commonly viewed as the preeminent suburban city, partly due to its being the pioneer in the development of railway and suburban underground links, which, as pointed out by Hebbert (1998, p.52) led by the turn of the twentieth century to the loss of the city's 'territorial integrity' due to competitive development of the land along the newly laid lines. On the other hand, London's plan for a green belt to prevent its urban edge from encroaching on the countryside has held strong as a psychological - if not entirely impermeable physical - barrier to growth since its implementation (Abercrombie, 1943). These two processes of urban growth and containment have been key components in contemporary critiques of London's evolution: leading to calls both for *non-plan* (Banham et al., 1969; Barker, 1999) and for restriction on unrestrained suburban development, in the Garden City tradition of urban planning. An additional critique focuses on the gradual spread of semi-planned development - frequently characterised as 'sprawl'. Adopting a different emphasis to this question from planning

historians such as Hebbert (1998) and his predecessors, we have argued from a spatial morphology perspective that such debates on the suburbanisation process require a more rigorous description of suburban build form in the context of theories of the urbanisation process (Vaughan et al., 2010a). Advancing developments on the urban fringe as a perpetually 'new' urban phenomenon - as implied by Garreau's 'edge cities' (Garreau, 1992), or as essentially novel spatial forms - as in Sieverts' (2003) interesting notion of *Zwischenstadt*, or 'in-between-city' - require sustained critical investigation that extends beyond the creation of neologisms that have become something of a suburban cliché. As Wunsch has pointed out, 'the differences between city and suburb are often indistinct' (Wunsch, 1995, p.643). Analysing the spatial morphology of urban form and structure over time is essential for gaining a better understanding of how cities emerge, grow and take shape. This is the aim of the research reported in this paper. Historical analysis of configurational trends of continuity and change allows scholars to better appreciate how the form of the modern city has a morphological, as well as a social, history. Change at one scale of urban space does not necessarily erase or even disrupt structural continuities at another, focusing attention on those areas of the network where different scales of potential movement coincide (Griffiths, 2009). Analysis of contemporary urban form without this historical perspective runs the risk (*ibid.*, p.653) of seeing the modern city as '*sui generis* without antecedents'.

Urban growth processes are not uniform, nor are they simply accumulative increases in building coverage or network connectivity. As Carter (1983) has pointed out, each change or addition has an impact on what has preceded it, both in the immediate surroundings and on the whole city. Accumulative changes are also subject to technological change (such as the motor car a century ago or the internet today) and the impact of technology on society (and vice versa), which will alter, or interrupt, the pattern of growth. Furthermore, as Whitehand has argued, suburban growth is not purely residential in its character, but is comprised of sequential developments of edge city land uses such as cemeteries, sewage works, playing fields and reservoirs, which can interrupt the subsequent pattern of growth so as to create 'belts' of open land between one phase of urban development and the next (Whitehand, 1974). This is particularly the case when considering urban growth over a long period of time and a suburban landscape as porous as London's - whether in the 1860s or today.

London's suburban fringes contain a large number of town centres of various sizes which play a vital role in the city's economic and social sustainability. Research into twenty of these centres has found that their ability to adapt to change over time has been strongly influenced by their situation on routes that contain flows of movement at different scales and by different social groups (Vaughan et al., 2010b). The way in which London's 'loosely woven road network' (Hanson, 2000) has contributed to the shaping and adaptation of its town centres over time provides a long-term perspective on the emergence of town centre land uses. The study of the changing character of suburban town centres over time enables a critique of notions of decline, currently at the forefront of any discussions on the future of the British high street, given that these tend to employ a retail-focused definition of the constitution of town centre success (Griffiths et al., 2013).

In this article we combine space syntax segment analysis of London within its outer ring motorway (the M25) with an account of changes in land uses over time to consider the significance of two suburban town centres as examples of emergent suburban landscapes with centres of activity that demonstrate distinctive 'spatial signatures' (Vaughan et al., 2010b). Four periods from the 1860s to today are analysed to measure the extent

to which their contemporary spatial configuration can be explained by a morphological evolution from a semi-rural porous network of streets, to forming part of Greater London's outer suburban network today. Similar to the work of Serra and colleagues in their study of Oporto's growth, we suggest that the way in which road networks grow can have a profound impact on their future use (Serra and Pinho, 2011). We also examine their proposition that rural grids can have 'spatial inertias that are difficult to overcome' (*ibid.*, p.378).

The focus on the suburban town centre is not accidental. Inspired by Garreau's work on 'edge city' (Garreau, 1992), Barker (1999) claims that out-of-town shopping malls will soon consign the 'anachronism' of the historical high street to the past. As we have pointed out in the past (Vaughan et al., 2009a), this language is typical of the generally superficial descriptions of such environments. Yes, a certain kind of popular image of the British high street, that of the 'butcher, the baker, the candlestick maker', is certainly becoming less representative of suburban town centres. However, whatever their historical veracity (and this is open to question), such popular images are marginal to any substantive understanding of what makes for the success of town centres. To note that aspects of the contemporary British high street are under threat should not be to dismiss the underlying settlement-growth dynamics that gave rise to the broad mix of socio-economic activities we associate with suburban centres. As Hillier has noted, the dynamism of 'edge city' is not restricted to the edge: it is the *pervasive* nature of centrality that allows cities to sustain themselves (Hillier, 1999; Hillier, 2009). Edge city developments are part of a fundamental process of urban growth. Our work has stemmed from a premise that a focus on the retail, *live* uses of the 'high street' (or in north American terms, 'main street') neglects the important role that the broader, *active* range of non-domestic uses play in sustaining the vitality and viability of town centres as a whole.

Here we reflect on how the relatively unplanned process of suburban growth might have the capability to exploit different possibilities of town centre morphologies. By measuring the intersection of different scales of potential path overlap, we also consider whether London's suburban town centres have survived due to their ability to sustain a 'rich and densely networked social life for different social groups' (Urry, 2002, p.259). A description of research methods and the case studies is followed by three sections of analysis: the first presents the spatial evolution of the two town centres and their environs in detail; the second analyses the emergence of the town centres in relation to the potential of the street network to create co-presence between people moving through and to the areas. The third section, which zooms in on the evolution of one of the town centre cases, seeks to establish whether its distinctive spatial properties can help explain its ability to 'weather' change. Here we echo Hillier's (2009) work on 'spatial sustainability', although with a greater emphasis on the historical dimension - the implications of this study for Hillier's work will be discussed in the conclusion.

2. Methods

In order to create a time series of network representations of the Surbiton and South Norwood street networks for the four historic periods between 1860 and 2013, a method called 'cartographic redrawing' (Pinho and Oliveira, 2009; Serra and Pinho, 2011) was employed. This was necessary because while the space syntax analysis techniques used require a vector line-based representation of the street network, readily available from the UK mapping agency, the historic map data was available in raster image format only. Cartographic redrawing is a method that allows for the non-destructive creation of chronologies of urban morphologies.

The process is carried out from the contempo-

rary period backwards, starting with the most accurate contemporary vector street network data from the UK Ordnance Survey national mapping agency, which forms the basis of all the historic street network representations. The contemporary vector line data is overlaid on the historic mapping for the first preceding period under investigation and all sections of road are deleted that are not present in that period, so that the street network matches the previous period. This is repeated for each preceding historic period for which the street network is required, creating an individual layer for each period. The process was carried out on a circular area that extended 6km beyond the contemporary town centre boundary. The total size of the area analysed is 226km^2 across the two case studies for the four time periods: c. 1880, 1910, 1960 and 2013 (see Figure 1, which shows the networks for the two cases over time, with the 3km area set within the full 6km contemporary extents).

The cases selected for study, Surbiton and South Norwood, were both part of a broader study which considered twenty cases around outer London, chosen by a geographically stratified random sample from all possible 113 cases of a similar size and situation between London's inner and outer orbital roads. Both cases are Victorian railway suburbs and are situated in South London. South Norwood developed on the back of a mid-nineteenth-century railway development adjacent to the major road between Croydon and London, with the high street running along the Croydon Road. The growth of Surbiton was also due to the arrival of the railway in the mid-1900s but, with the same railway having been

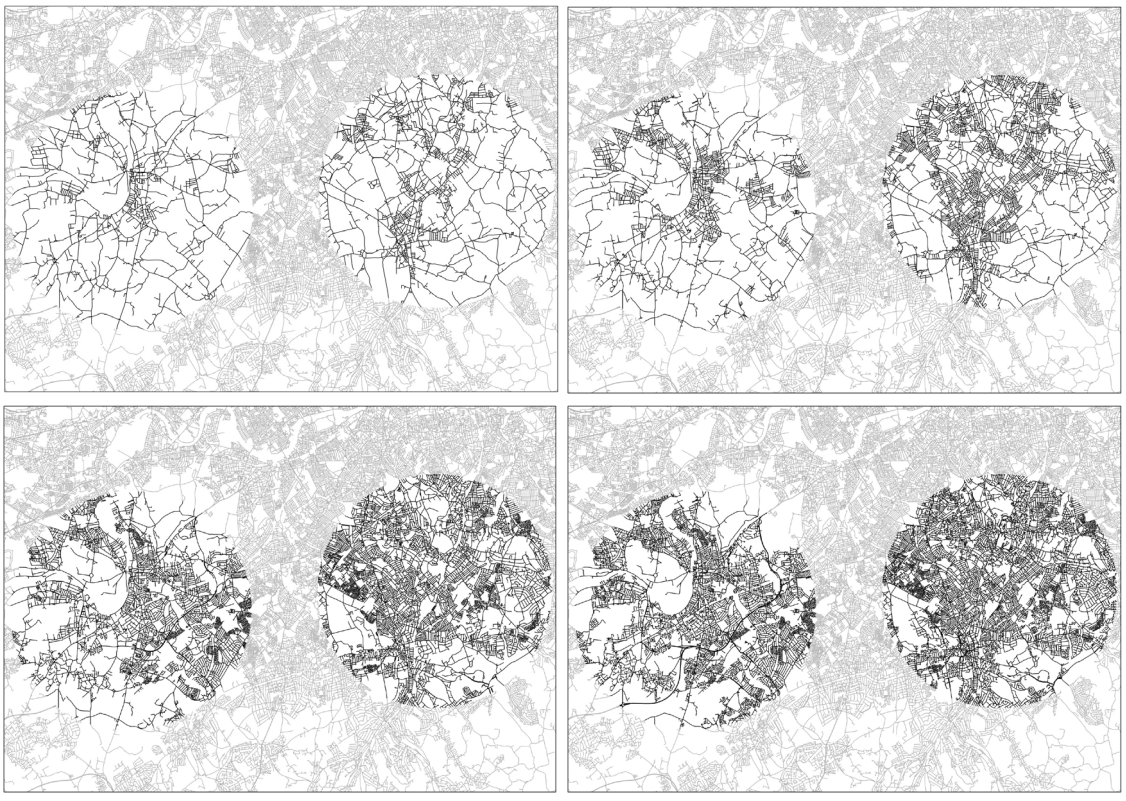


Figure 1:

Road network models centred on South Norwood (left) and Surbiton (right) captured using cartographic re-drawing technique.

c.1880, 1910, 1960 and 2013 - left to right, top to bottom.

rejected by the residents of nearby Kingston, Surbiton's was a greenfield development, with the high street a planned extension from the historical road network running between London and the south of England. These suburban centres have been selected as contrasting morphological examples of town centres with distinctive demographic profiles. While Surbiton is broadly affluent and archetypally 'suburban' with its largely middle-class residential population, South Norwood is rather more urban and with a wider demographic profile[1].

The analysis of two apparently contrasting town centres should also help to identify any common morphological aspects. The town centre boundary was a much more extensive area than is usually considered in typical retail analysis studies. It was defined according to the location of all non-domestic land uses within walking distance from the centre. In our work we intentionally draw a wide net around the 'active centre' in order to capture the rich mix of activities - commercial, production, communal and leisure - that potentially contribute to a centre's liveliness (Vaughan et al., 2009b). Non-domestic activities are then classified according to a standard schema[2]. In the case of the three historic periods of c.1875, c.1915 and c.1960, archival copies of business directories of the time were obtained, from which the detailed uses for each street address were recorded in a spreadsheet and classified as before[3]. The land-use data were matched to the building address on the historical Ordnance Survey map and then georeferenced in a GIS platform. The buildings from the historic record were redrawn using a new digitisation technique (Dhanani and Jeevendrampillai, 2012) that enabled the individual building plots to be digitised for each period and land uses to be assigned to individual building plots on the basis of detailed work by project researchers

Notes:

[1] *For morphological histories see Griffiths et al. (2010).*

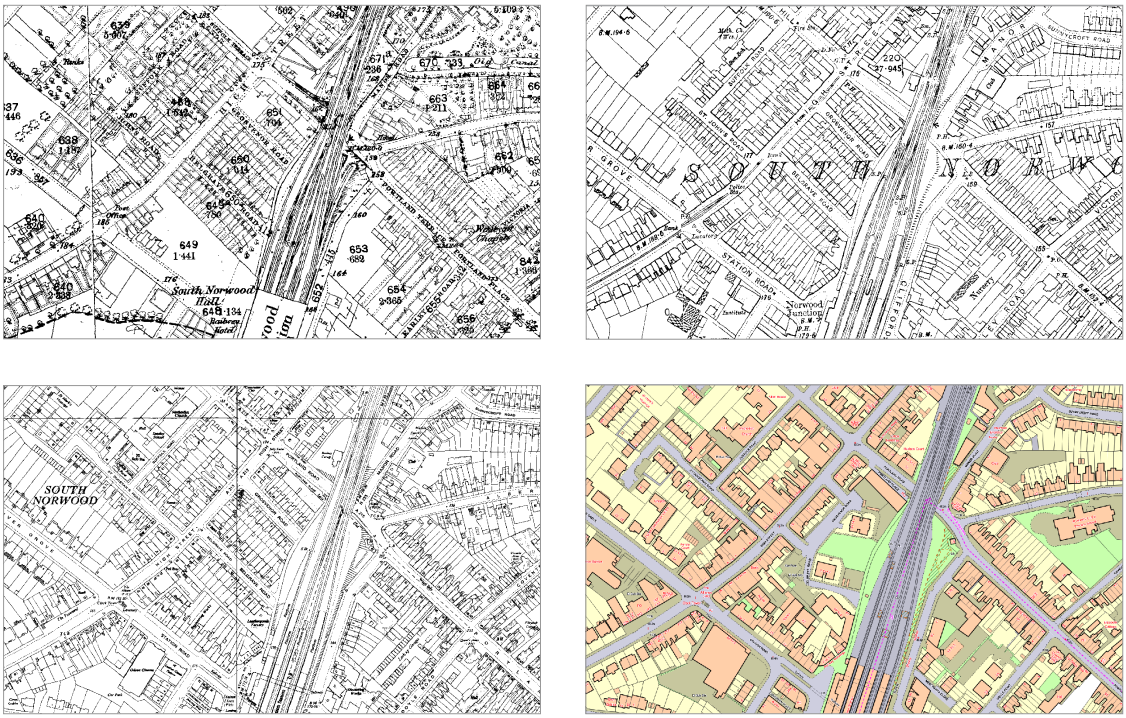
[2] *See figure caption in Figures 6 and 7.*

[3] *Business directories were obtained from the Local Studies Libraries in the London Boroughs of Croydon and Kingston-upon-Thames, using Philipson Almanac and Directory for Kingston, Surbiton and Norbiton (1876); Kelly's Kingston, Norbiton, Surbiton and District Directory (1915) and Kelly's Directory of Surbiton (1956) for the Surbiton cases and Ward's Croydon Directory (1874), Ward's Croydon Directory (1915) and Ward's Croydon Directory (1956) for the South Norwood cases.*

Figure 2:

Ordnance Survey maps for South Norwood town centre.

c.1880, 1910, 1960 and 2013 - left to right, top to bottom. Scale 1:1500.



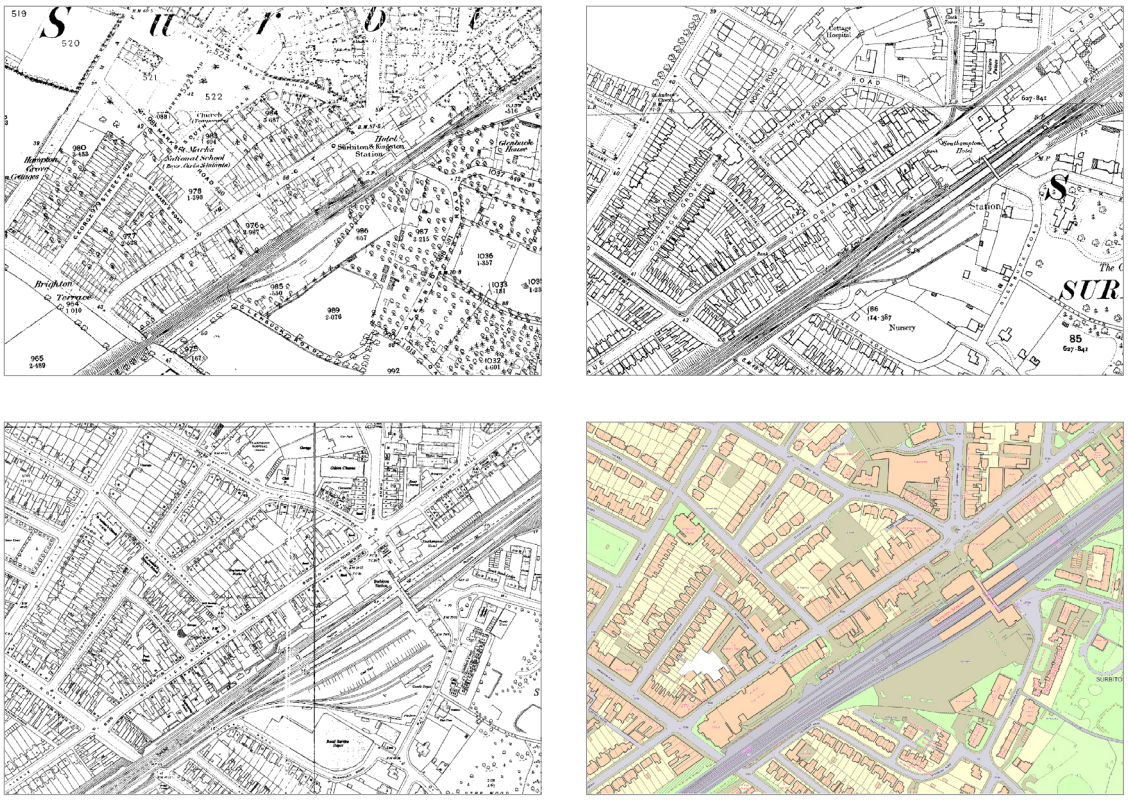


Figure 3:

Ordnance Survey maps for Surbiton town centre.

c.1880, 1910, 1960 and 2013 - left to right, top to bottom, respectively. Scale 1:1500.

with local knowledge[4]. (Figures 2 and 3 show the base maps used for redrawing the buildings and assigning them land-use classifications.) Whilst the scope of this article does not allow for exploration of the detailed distribution of the land uses, which is planned for future publications, here we consider a comparative temporal cross section, taken by identifying the streets within each town centre that have had non-domestic land uses along them over the four periods and then analysing the spatial properties of the resulting area as they shift over time. We use the term 'comparative boundary' to describe this common area[5].

The two measures that are used in this research are *choice* and *integration* angular segment analysis. These are variants of the *betweenness centrality* and *closeness centrality* measures that are commonly used in network analysis. The specific measures that are employed are angular segment-length weighted choice to account for the utilisation of a road centre-line network model (Turner, 2007; Dhanani et al., 2012) and angular segment integration. The results are presented for a central 3km radius around the town centre and the maximum radius of analysis is 3000m, though the analysed network extends 6km beyond the town centre. The larger contextual area was included to avoid edge effects.

Hillier et al. (1987) suggested in an early space syntax study that it is likely that a correlation between integration and choice might 'index the degree of correlation between these two types of movement pattern... the degree of "movement interface" between inhabitants and strangers' (p.237). However, it is only in recent years that the analytic capability has been developed to examine this

Notes:

[4] *Ashley Dhanani, Ruthie Carlisle, David Jeevendrampillai, Nikolina Nikolova and Patrick Rickles.*

[5] *The comparative boundary is defined as the lowest spatial common denominator for the areas, covering all time periods (1880s, 1910s, 1960s, and 2013) and was used to create a common geographical area to study change in street configuration, building morphology and land uses within it. Data outside of this boundary were captured for contextual purposes and to enable cross-sectional analysis.*

relationship. Whilst choice approximates a measure of through-movement potential and integration approximates a measure of to-movement potential, where the highest values for both measures overlap to the greatest degree will create, as termed by Hanson 'different modes of spatial co-presence and virtual community' (Hanson, 2000, p.115). As has been proposed in a previous article using this analysis (Vaughan et al., 2010b), the location of greatest overlap is likely to be where the qualities of centrality associated with suburban movement economies are most likely to be seeded.

In earlier research we studied 'movement interface' by analysing movement potentials for integration and choice at different scales and found that there was a *spatial signature* for the studied cases that differed across the twenty cases studied there (Vaughan et al., 2010b). Here we repeat this analysis in greater detail by considering where peak correlations exist for each case and across the four periods. This analysis of co-presence is carried out through time to ascertain the changing peak locations of co-presence in the network.

3. Space syntax analysis of changing spatial structure through time

This section presents the results of the space syntax analysis of the changing structure of choice and integration for the two case studies of South Norwood and Surbiton. Here 800m and 3000m are presented as they respectively constitute a representative walkable scale and the largest radius for which the network can be considered without edge effect. Referring back to Figure 1, the increase in network extents and links over the period being studied is especially notable in South Norwood, which is closer to the city centre. In this case the total road network length increases from 156km to 430km within the 3km area of analysis. This represents an increase on average of 9km of road network per square kilometre, reaching a current density of 14.5km of road network per square kilometre. In Surbiton the total road network length increased from 134km to 372km over the period of analysis. This represents an increase of 8km of road network per square kilometre, reaching a total density of 12.5km of road network per square kilometre. In comparison to South Norwood, Surbiton can be said to have experienced a lower rate of road network densification and overall to be less densely filled in by road network. In both case studies, analysis of the centre 3km radius around the contemporary town centre found that the average values for choice altered over time with a net fall in value, but the highest values consistently increased as did the standard deviation. Integration on average increased over time across all scales in both case study areas as did the highest value and standard deviation. Whilst these trends can be understood as the process of urbanisation it must be considered within the suburban context as the morphological development of suburbs in the inter-war and post-war period exhibit unique spatial properties.

Figure 4a shows the values for choice and integration at radius 800m in the South Norwood study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom); Figure 4b shows the same sequence for 3000m radius of analysis. From these figures it can be seen that the morphological evolution of the area follows a pattern, building upon and between previous structures of choice and integration to reinforce and enlarge them, with the creation of new centres at both local and regional scale. Furthermore there is a clear and temporally persistent spatial divide between two regions of the study area.

A close reading of the four periods shows measurable shifts in the areas of peak integration and choice, with an initial state of multiple local cores of integration and choice, linked together weakly. The period of the turn of the twentieth century shows an increase in the prominence of

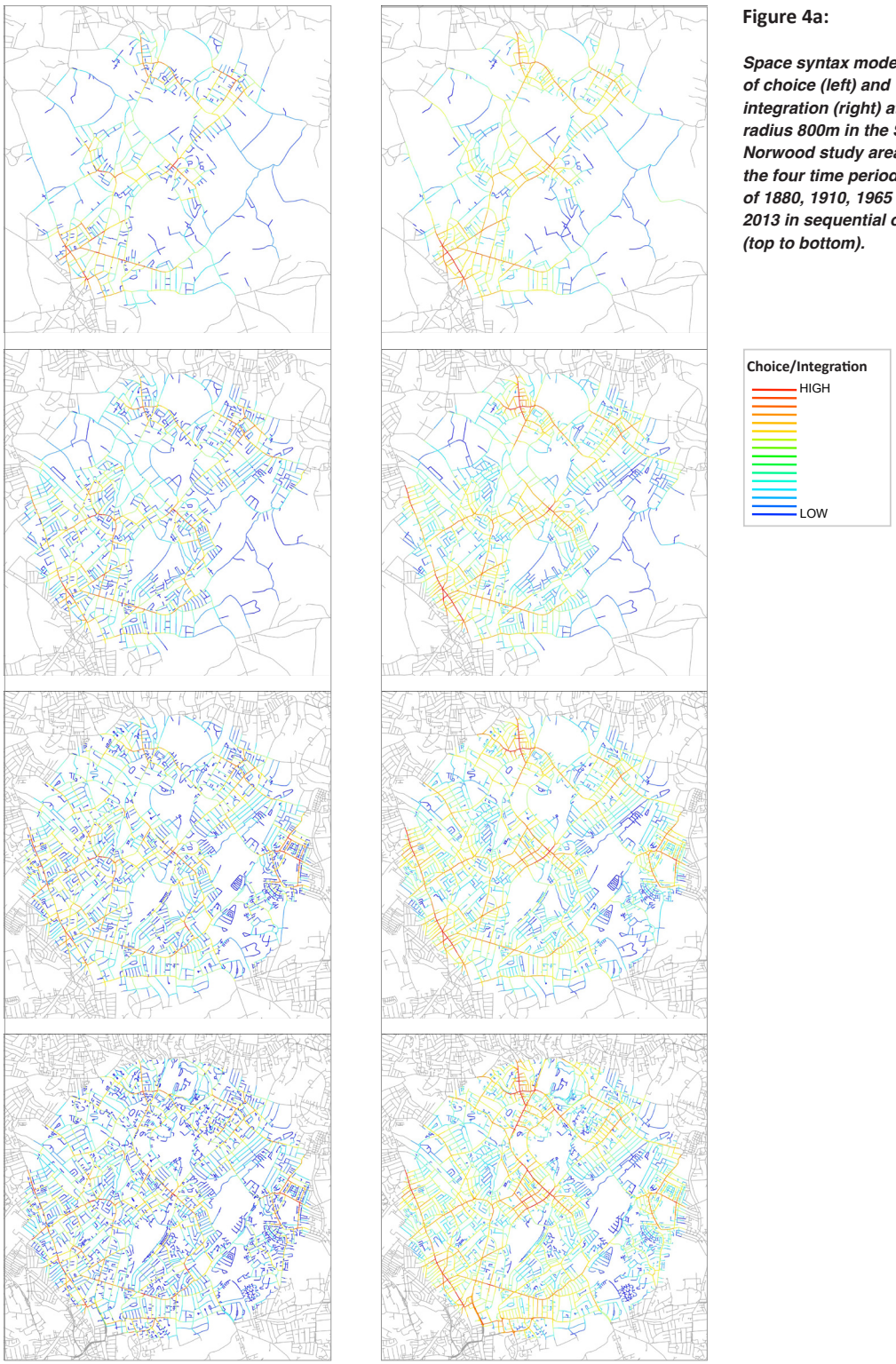
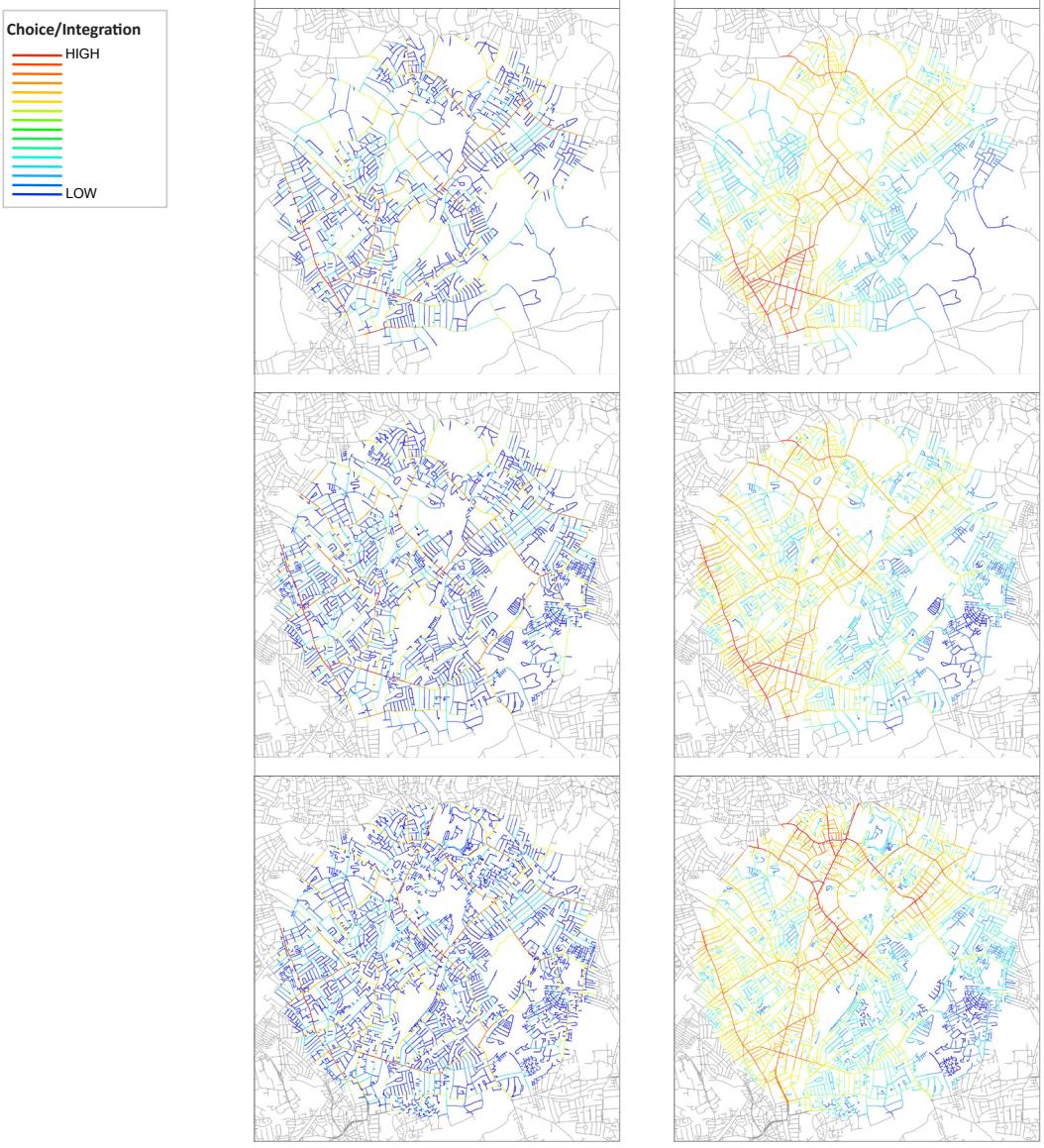


Figure 4a:

Space syntax model of choice (left) and integration (right) at radius 800m in the South Norwood study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom).

Figure 4b:

Space syntax model of choice (left) and integration (right) at radius 3000m in the South Norwood study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom).



centres following a densification of the road network around pre-existing centres, with the exception of a strong local centre emerging around the old road connecting the nearby large centre of Croydon - although it doesn't show strong links onwards to London, despite it being a main link to the city at the time. The subsequent periods show increased densification of the network but then major shifts in the most recent period, where an offset in the linear structure of integration occurs. This is due to the introduction of an elevated road-way connecting into the centre of Croydon which reconfigures the local area. At radius 3000m the changes are more dramatic: the previously highly integrated area around the London-Croydon route is no longer the most prominent integration core; this has now moved to areas around South-Norwood and Crystal Palace where there has been a strong increase in the density of the road network around the centres.

One spatial theme that can be seen to run through this entire time series analysis is the difference in syntactic properties of the north-western and south-western halves. Throughout the time period studied, the south-eastern half has only one locally strong centre develop at radius 800m of analysis and no significant centres at radius 3000m of analysis. The region also does not have any strong routes of choice connecting across or within, and it contains the most locally and globally segregated areas. These areas are suburban housing estates that have been built in such a spatial manner as to create circuits of segregation that do not have any impact on local properties of the grid since they are primarily composed of curvilinear dead-ends. The build-out of the area gathered pace only in the period 1910 onwards, in contrast with the other areas of the network which had some form of spatially established centres in the earliest period of 1880. From this it could be said that South Norwood is actually a morphologically divided area. Significantly the divide occurs very close to the train line running through the area, bringing to mind the idiomatic expression of being on 'the wrong side of the tracks'. The north-western half experienced growth prior to the development of spatially segregated ideologies of suburban domesticity, locking it into a more spatially integrated mode of development.

Figure 5a shows the values for choice and integration at radius 800m in the Surbiton study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom); Figure 5b shows the same sequence for 3000 metres radius of analysis. From this sequence of maps the general trend that can be seen is, similarly to South Norwood, the reinforcing and growth of pre-existing centres, but there is a notable intervention of road network infrastructure that dramatically shifts the patterns of choice and integration at radius 3000m of analysis and to a lesser extent at radius 800m of analysis.

Whilst the 1880 map shows a clearly defined central area of high integration at both scales, focusing on the older centre of Kingston-upon-Thames (the cluster of reddish lines at the centre-north of the map), the roads aligning the river itself emerge as significant. The spatial coincidence of high choice and integration at radius 800m is similar to that of South Norwood, also indicating locally coherent systems of to- and through-movement, although high integration network elements are more continuous than in South Norwood, indicating that it is a less fragmented area of spatially distinct settlements. The spatial transformations that take place in the period 1910 to 1960 are the most significant of any time period in either case study. These relate to the construction of the curvilinear A3 Kingston Bypass running along the south-eastern edge of the area, resulting in a decisive shift in the syntactic structure of the area, by creating centrality around a wholly new spatial structure without reference to pre-existing pathways. It is interesting to note that by drawing integration and choice to the south of the area, the bypass enhances both spatial attributes

Figure 5a:

Space syntax model of choice (left) and integration (right) at radius 800m in the Surbiton study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom).

Figure 5b:

Space syntax model of choice (left) and integration (right) at radius 3000m in the Surbiton study area for the four time periods of 1880, 1910, 1965 and 2013 in sequential order (top to bottom).

for the north-south connections between Kingston and the bypass itself. This may in fact act to balance out the heavy northerly choice and integration bias that the size and density of Kingston creates in the area.

Both study areas have unique spatial development trajectories and specific features, but also similarities. They both show the development of new configurational centres away from the primary historic centres due to their later development and greater scope for densification; and the development of choice routes between these centres, creating links of through-movement across the space. South Norwood's peculiarity is in the strong divide between the north-western and south-eastern halves that persists through time. Surbiton's unique feature is the Kingston Bypass that creates a whole new type and scale of spatial structure entirely separate from the historical spatial structure. This change acts to create new types of centrality and movement potentials due to the infrastructure of the bypass being designed solely for vehicular movement.

4. Network co-presence

Whist the descriptive analysis of the changing spatial properties of South Norwood and Surbiton serves to illustrate their overall spatial development, a more in-depth analysis of what the choice and integration values actually show is necessary. In the description of the primary space syntax results it was suggested that choice and integration follow each other in the locations where the peak values develop, but integration shows the areas of road network densification and choice illustrates the primary linkages between these integration cores; there is an overlap of the highest values in only a small number of locations and this relationship differs between scales of movement potentials.

Where the overlap between the highest values of choice and integration occurs this article suggests that these can be characterised as locations of high to- and through-movement potentials, and what this paper terms 'co-presence'. Whilst co-presence normally refers to spatial proximity between individuals in space (Urry, 2002) the term is used here in a spatial sense to describe locations where the network is structured in such a way as to bring together through- and to-movement potentials, to bring about the possibility for co-presence to occur. It is proposed that in the locations where there is the greatest overlap between the highest values for choice and integration, there is the highest likelihood of the occurrence of activities associated with town centres.

The configurational analysis was designed to enquire whether those elements of the street network associated with town centre activities displayed discernible syntactical properties in terms of segment-angular choice and integration analysis. This in turn raised the question of whether the non-domestic heartlands of the street network tended to become notably more or less differentiated over time as the centres grew, and whether they differed configurationally from their residential hinterlands. Having established in earlier analysis (Griffiths et al., 2013) that the non-domestic streets have consistently and significantly higher rates of integration and choice than all other streets within a 3km reach, the following analysis considers the town centre as a spatial unit in its own right.

As explained earlier, in order to have a variable independent from the contemporary UK planning definition of what constitutes a town centre, which tends to focus on peak retail and office uses, all non-domestic uses were captured within a comparative boundary for four time periods. Angular segment-length weighted choice and angular segment integration were calculated for all streets within the comparative boundary for radii up to 3000m as well as *n.* In this analysis we focus on 400m, 800m, 1200m, 1600m, 2000m and 3000m

South Norwood	400	800	1200	1600	2000	3000	4000
1880 (n=58)	**.695**	**.651**	**.631**	.607	.563	.588	.612
1910 (n=90)	.627	**.698**	**.665**	**.660**	.622	.535	.609
1960 (n=94)	.642	**.727**	**.723**	**.697**	.669	.633	.661
2013 (n=107)	.639	**.742**	**.717**	**.708**	.696	.633	.600

Surbiton	400	800	1200	1600	2000	3000	4000
1880 (n=41)	.386	.761	.668	**.814**	.736	**.778**	**.763**
1910 (n=48)	.567	**.776**	.702	**.858**	**.813**	.740	**.790**
1960 (n=61)	.417	**.774**	.653	.750	.728	**.815**	**.787**
2013 (n=76)	.674	**.892**	**.862**	**.777**	.745	.761	**.777**

Table 1:

Highest correlation between integration and choice at the same radius, selecting only the streets within the comparative boundary, highlighting top three correlations for each epoch in bold.

radii, with choice and integration for each radius in turn correlated using bivariate regression analysis within Statview statistical software (Table 1). The unit of analysis was the average space syntax value for all segments between two junctions on each road alignment[6].

Bearing in mind this analysis focuses on the set of streets and their immediate environs which had continuous non-domestic usage over study period, two clear findings emerge:

1. Throughout the four periods both cases exhibit a constant correspondence between choice and integration, suggesting a robustness in the way in which the town centre relates to its wider street network setting;
2. At the same time each of the cases has a differing signature in the correlations at particular scales. Whilst Surbiton has a distribution of high as well as low scales within which there is a correspondence throughout the periods, South Norwood has path overlap only at relatively low scales, with no overlap at the larger scales. Surbiton has a slightly different pattern on the ground: like South Norwood, it is segmented by the railway line and at a very large scale, suffers to a certain degree from the coming of the Kingston Bypass; yet possibly because the bypass links back to historic road alignments, such as Ewell Road, it serves to reconnect what it divides elsewhere.

Notes:

[6] *See Figure 1 in Griffiths et al. (2013): In order to reform and join together the fragmented road segments created by the GIS-derived road centreline map, 'junction-to-junction sections' (in short, junction segments) were created from all segment lengths of the network situated between road junctions.*

Putting aside the differences in the specific spatial signature of each town centre (Vaughan et al., 2010b), these patterns of correspondence represent the structural continuity of the built form/movement interfaces in each of these places. By looking at the relationship between the two types of movement pattern, we have supporting evidence for structural continuity across the sample. Arguably this method provides a way of defining structural resilience: despite the massive spatial change undergone in these areas, this movement interface index remains consistent over time. Perhaps paradoxically, change can produce continuities (and vice versa), particularly where different scales of urban space overlap (Griffiths, 2009).

Nevertheless, this generalised analysis of non-domestic densities warrants further exploration to consider different types of town centre activity separately, in order to determine whether there are any shifts in the spatial configuration of the different land uses, given that the literature would suggest that 'high streets' (i.e. peak town centre activity) would tend to become more focused over time and more pronounced in their spatial differences from their hinterland. The start of such exploration can be seen in an earlier conference paper (Griffiths et al., 2013) and further investigation of another two London cases will follow in due course. Here we have chosen to explore the cases in greater detail in order to provide a descriptive account of changes to their land-use patterns over time.

Figures 6 and 7 show the results of compiling land-use and spatial network data for the four periods and in the two case studies. The space syntax analysis shown here is integration radius 800m. Whilst it is important to note that in both cases there is clear evidence of continuity of activity throughout the long period studied and that both have a similar spatial discontinuity created by the railway line dividing the town centre to its south, there are some striking spatial differences, which help to explain the findings above regarding overlapping networks. The Surbiton maps show a well-established and continuous network of loops of integrated streets and rings of circulation. The distribution of the land uses follows a corresponding spatial logic. The earliest map already shows a range of non-domestic land uses arrayed along the road outside the station (with the station hotel punctuating the west-east length of the street), and this continues around the corner to the west and then in a 'T' to the north towards Maple Road. In the past the street's land uses involved activities including a school, church, doctors and other professionals, and today continues in the form of pubs, restaurants, hairdressers and other services, in contrast to the offices and shops closer to the train station. It is evident that over time there was an increase in activity to form an almost complete circuit of non-domestic activity, with a commensurate increase in mixed-use buildings, frequently combining an office with business services. Other land uses which tend to fall beneath the radar of smaller town centres are instances of small-scale manufacturing, typically nestled in a courtyard or in side-streets behind the main throng of the high street, but close enough to benefit from its proximity - whether to use the coffee shops for meetings, or the services to support the business. Similarly, professional and non-professional services, such as solicitors or chiropodists, have taken premises that benefit from proximity to the peak flows of movement in the centre, but which do not need a live frontage on the street. Along with a spatial network that supports different scales of movement flows through and to the centre - as we have stated in previous publications - the rich mix of commercial, communal and business activities creates an interdependence between shopping and other non-domestic activity by ensuring the town centre is not dependent on a single source of activity to draw people in to use it.

The spatial network patterns are not quite the same in South Norwood, which - apparently due to

Figure 6:

South Norwood 1880, 1910, 1960 and 2013 (top-left, top-right, bottom-left, bottom-right, respectively), with contemporaneous background mapping and land uses, overlaid with segment angular integration 800 metres.

Map scale 1:1500. The comparative boundary is marked with a dotted black line.

GROUP	Classification	Code	GROUP	Classification	Code
Community Services		**CS**	**Offices and commerce**		OC
	Outdoor amenity and open space	c1		Government	o1
	Sports facility and grounds	c2		General commercial	o2
	Allotments and city farms	c3		Offices	o3
	Cemeteries and crematoria	c4	**Service Sector**		OC
	Indoor entertainment	c5		Professional services	o4
	Libraries, museums and galleries	c6		Non-professional services	o5
	Places of worship	c7	**Retail**		R
	Medical and healthcare services	c8		Shops	r1
	Education	c9		Shops with manufacturing	r1-ms
	Local Government	c10		Financial	r2
	Community services	c11	**Third Space**		TS
Industry		M		Restaurants and cafes	r3
	Factory workshop and premises	i1		Public Houses and bars	r4
	Store, distribution and premises	i2		Hotels, boarding and guest houses	r5
	Industrial services	i3	**Other**		
	Agricultural	i4		Unclassified	UC
				Vacant	V

Figure 7:

Surbiton 1880, 1910, 1960 and 2013 (top-left, top-right, bottom-left, bottom-right, respectively), with contemporaneous background mapping and land uses, overlaid with segment angular integration 800 metres.

Map scale 1:1500. The comparative boundary is marked with a dotted black line.

GROUP	Classification	Code	GROUP	Classification	Code
Community Services		**CS**	**Offices and commerce**		OC
	Outdoor amenity and open space	c1		Government	o1
	Sports facility and grounds	c2		General commercial	o2
	Allotments and city farms	c3		Offices	o3
	Cemeteries and crematoria	c4	**Service Sector**		OC
	Indoor entertainment	c5		Professional services	o4
	Libraries, museums and galleries	c6		Non-professional services	o5
	Places of worship	c7	**Retail**		R
	Medical and healthcare services	c8		Shops	r1
	Education	c9		Shops with manufacturing	r1-ms
	Local Government	c10		Financial	r2
	Community services	c11	**Third Space**		TS
Industry		M		Restaurants and cafes	r3
	Factory workshop and premises	i1		Public Houses and bars	r4
	Store, distribution and premises	i2		Hotels, boarding and guest houses	r5
	Industrial services	i3	**Other**		
	Agricultural	i4		Unclassified	UC
				Vacant	V

the lack of local contiguity of streets both east-west and north-south - has strong connections at the urban scale which are not carried through locally. The segmentation of South Norwood's town centre by a railway line as well as by a major road network seems to have an effect on its ability to link up at more than one scale. Indeed, closer examination of its network reveals a lack in grid deformation or intensification around the main roads whilst at the larger scale it connects better for choice than for integration. This is carried through into the distribution of land uses. Although South Norwood has weathered the challenges of socio-economic change quite well - it is, after all, still functioning without too many of the markers of decline, such as closed shops - the relative lack of deformation in the local grid has evidently had an impact over time and, notably, the amount of non-residential activity around the overhead railway tracks has contracted significantly. Such marked differences provide supporting evidence for other indicators of the centre's relative lack of social-economic success (although of course other contributory factors may have been involved).

5. Conclusions

This article has presented the initial findings of an investigation into the evolution of the spatial structure of two areas of peri-urban London. Whilst it has shown that there are commonalities in the underlying spatial morphology of suburban built form, it has also demonstrated how the spatial morphology is unique in both cases and cannot be simply described as generically suburban.

Recognising the peculiarities in the spatial evolution and contemporary form of the two case studies is important in creating an understanding of their socio-spatial functioning over time. In the case of Surbiton the large infrastructural intervention of the Kingston Bypass fundamentally changed the spatial structure and trajectory of growth, both in terms of the network relationships and the locations of built form. In contrast South Norwood did not experience large infrastructural interventions on the spatial scale that Surbiton did, but it exhibits a strong morphological divide along the north-east south-west axis. In the south-eastern area there is very little network co-presence or development of built structures associated with high levels of potential through- and to-movement.

From this analysis it can be said that understanding peri-urban development involves a recognition that it is neither a unitary nor a uniform process but one that requires a careful examination both of how the generic dynamics of urban growth, such as those set forth in Hillier's theory of the urban movement economy, are realised in particular historical and topographical conditions, and of the emergent complexity of the suburban morphologies that this process produces. Understanding how to make suburbs and suburban centres adaptable and socially functional requires a specific understanding for each case with regard to its past pattern of growth as well as to its wider spatial setting. These findings add further confirmation of our earlier work (Vaughan et al., 2010b) which proposed that - particularly in smaller centres - the 'active' town centre that extends beyond the area of the high street is a distinctive social-morphological entity in its own right, and whose morphological integrity is essential for the long-term success of such centres. We showed there and further confirmed here that exclusive focus on the 'live centre' and its retail and office activities tends to overlook the importance of synergy between all non-domestic land uses.

A recent report by the UK government Department for Business, Innovation and Skills on Understanding High Street Performance argues for a '21st century agora', with the town centre becoming a 'multifunctional destination, with retail playing a part alongside community, public service, leisure, cultural and civic uses' (BIS et al., 2011, p.xi). The

report affirms the emphasis on achieving a synergy of uses, stating that:

> '…non-commercial activity is missing from current assessments of high street activity. The presence of a Citizen's Advice Bureau or library can be as important in drawing footfall as a café or fashion store; the use of buildings as student accommodation could indicate a viable market in convenience shopping' (*ibid.*, p.xv).

Since the early days of space syntax considerable progress has been made in bringing innovations from mathematics and computer science to understanding how the built environment functions as an emergent system of, as Jane Jacobs (1961) famously argued, 'organised complexity'. Whilst the suburban street network is frequently dismissed as being a problem of sprawl, the research presented here suggests that the presence of organised complexity at the edge of Greater London's urban network continues to afford built-form adaptability, which sustains the multi-functionality of land use over time. Just as urban centres serve this purpose, smaller 'suburban' centres do the same, serving as mechanisms for maximising the exchange of goods, information or services. As Hillier (1996, p.180) has stated: the urban grid '…is the means by which the town becomes a "mechanism for generating contact", and it does this by ensuring that origin-destination trips take one past outward-facing building blocks *en route*, That is, [urban grids] allow the by-product effect to maximise contact over and above that for which trips are originally intended'. Indeed, we might say, given the pervasive nature of centrality, that this process is evident at all scales of urban space.

The article also proposes that a distinguishing feature of traditional town centre morphologies is not simply the nostalgic vision of 'mixed uses' but rather that a process of 'mixing uses' is what the spatial morphologies of high streets, embedded in their hinterlands, are particularly good at achieving - whatever this might mean in different historical periods. Fortunately, the tide seems to be turning on this point, with both government agencies and major design consultancies taking note. A recent report in the Huffington Post quotes a consultant on Arup's foresight and innovation team as saying 'there needs to be a move away from thinking high streets are just about shopping'.[7] Yet it is quite one thing to think it and quite another to know *why* this should be the case. Understanding more about how the movement economy operates in different social and historical-geographical contexts is necessary to help local policy-makers and investors in making better decisions to support its aptitude for 'mixing'. A historical perspective on this process can help in showing how the high street - even retail on the high street - is not one thing, but many things.

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Notes:

[7] *http://www.huffingtonpost.co.uk/2013/01/18/future-of-british-high-st_n_2505566.html [Accessed 5 June 2013].*

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