Urban morphology and syntactic structure: A discussion of the relationship of block size to street integration in some settlements in the Provence

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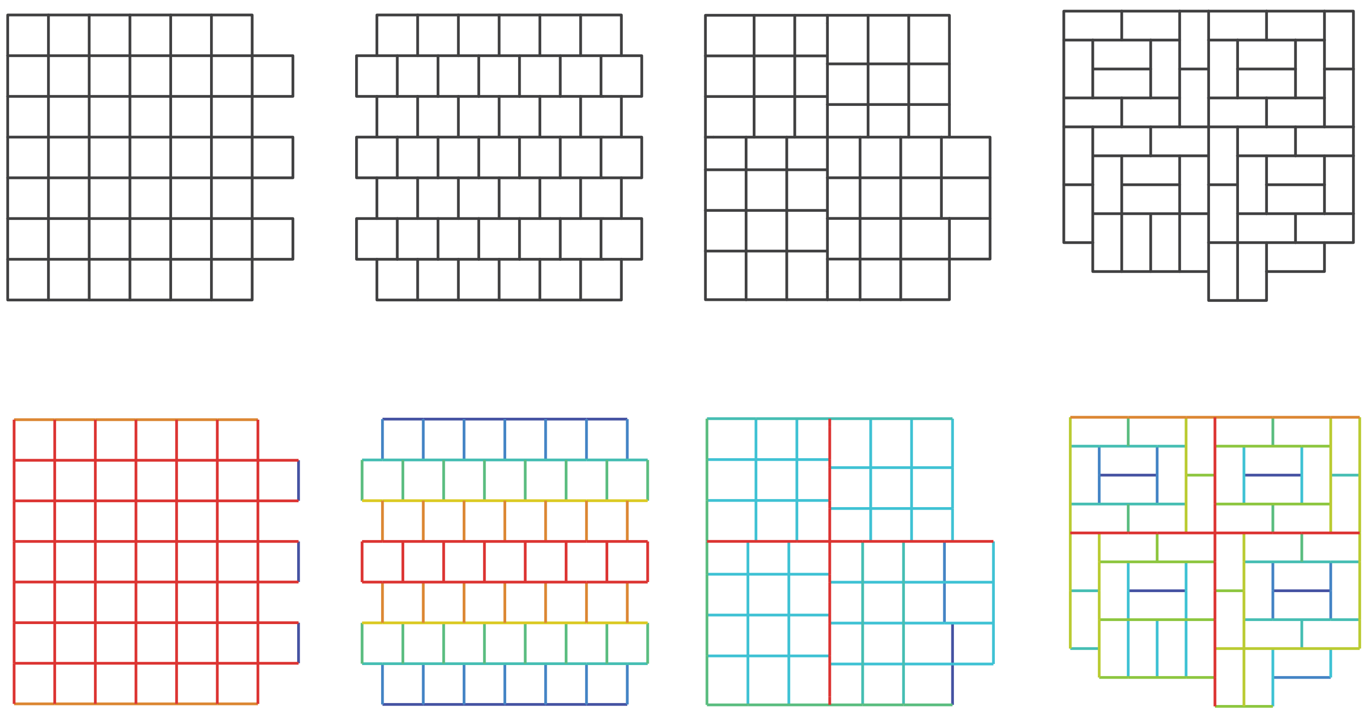

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The paper discusses the relationship between the syntax of street networks and the differentiation of the size of urban blocks in a sample of small towns and settlements. The argument is in four parts. In the first part it is demonstrated, through design games, that the differentiation of streets by integration is linked to the differentiation of blocks by size. In the second part, it is shown that in a small sample of towns in the Provence, small blocks are not associated with more integrated streets but are distributed throughout the street network. The demonstration is based on an original method for studying the block size in relation to street integration. In the third part, the historic evolution of these particular towns is shown to involve the rationalisation of their integration core: integrated streets become better aligned and wider, and reach more directly into all parts of the town. However, the historic relationship between integration and block size is also based on mixture rather than a linear pattern of association. The final part uses these findings to advance a speculation about the origin of the syntax of these towns as compared to the syntax of the smaller settlements that Hillier and Hanson characterise as 'beady rings'. This leads to a discussion of some of the abstract syntactic generators originally presented in *The Social Logic of Space*. In short, the final section of the paper argues that the lack of linear association between small blocks and integrated streets, in this particular sample, points to the emergence of gradually more complex generators of town form, generators which presuppose the ideas of the urban block and the street. These act upon the seeds of prior small aggregations, generated by simpler rules of adjacency.

Keywords:
Urban morphology,
space syntax,
block size,
Provence.

Introduction: Blocks, streets, and syntactic structure

Evidently, streets and blocks are mutually dependent and interacting constituents of urban morphology: smaller blocks imply more closely spaced streets and shorter distances between intersections; regular street grids imply a family of standardised block dimensions and shapes; and, as important, the 'life of the street' is affected as much by its extent, alignment, connectivity, dimensions and sectional design, as it is affected by the design of the block faces at any particular point along the street (Anderson, 1978). And yet, the question of whether there are systematic relationships between the structures of streets and blocks is not addressed in the literature as much as one might expect. Take for example, Jacobs' (1993) seminal book on streets. The first half describes and compares the dimensions and design of individual streets. The second half offers a visual comparison of the fabric of streets and blocks within a sample of square-mile areas extracted from many different cities around the world and drawn to the same scale and by the same conventions. The exercise is an acknowledgment of the fact that individual streets are parts of systems of streets surrounding and defining patterns of urban blocks; they cannot be considered in isolation. The sample illustrates differences of configuration (orthogonal or radial, regular or irregular), connectivity (continuously linked systems or branching systems with cul-de-sacs), scale (dense or sparse fabrics, small or large blocks) and composition (homogeneous or heterogeneous urban fabrics). These differences, however, remain heuristic and no method is offered for creating a systematic classification, even less a quantitative one. Marshall (2005) fills the gap left by Jacobs regarding the systematic classification of street patterns, but provides no equally explicit theorising about the urban block. On the other hand, Panerai, Castex, Depaule and Samuels (2004) discuss in detail the transformations of urban blocks in recent history. They review, in particular, the interface between block and street but give less emphasis to the types of street networks within which the transformations of blocks take place. Furthermore, their work offers no quantitative underpinning to the development of block and street typologies, let alone a quantitative analysis of their interaction.

Against this background, the method for the description of urban form proposed by Berghauser-Pont and Haupt (2010) lends itself admirably to the quantitative description of block morphologies according to the way in which they dispose of built volumes over the area of the block (density of development, proportion of open space on the ground, connecting spaces left between and around buildings). It has been pointed out (Steadman, 2014b) that in this regard such an approach represents a productive elaboration on the foundations of quantitative urban morphology laid by Martin and March (1972). The method explicitly factors in the density of streets or paths (total path length per area, as well as average distance between streets). However, it does not set out to encompass the properties that individual streets or street segments have by virtue of their position within a larger network. One attempt to bring within the scope of the same analysis the properties of blocks (density of development, closed or open perimeter, amount of open space) and the properties of streets (continuity and connectivity) was made by Gil, Beirão, Montenegro and Duarte (2012). Albeit, in this case, the aim was the development of an analytical process for identifying typological groupings in empirical data by using k-means clustering analysis rather than the development of explicit theory regarding the relations of blocks and streets.

Thus, the question of how the structure of street networks relates to characteristics of blocks remains open. In this paper we address a limited part of this larger question. We ask how the syntax of street networks interacts with block size. This choice of focus is not incidental. Block size and shape are perhaps the two properties of blocks that most closely interact with the arrangement of streets. They are also less likely to change over time, as property boundaries, land use, development patterns and regulatory frameworks change. Dealing with block size is a first step towards better understanding how block patterns and street patterns interact. In the literature of space syntax the question is not entirely new. The idea that the street grid is locally intensified in areas recognised as local or global centres (Hillier, 1999) implicitly points to block size: 'intensification' refers to the fact that greater street length is accessible within a buffer of metric (length) or directional (number of turns) network-distance. As a result, there is a greater density of interface, or contact, between building fronts and streets, creating more opportunities for various kinds of exchange - of things, information or ideas. Such intensification is possible only if smaller blocks are present, compared to areas in which the grid is thought to be less 'intensified'. However, traditional syntactic measures, such as axial integration, do not explicitly express metric properties; for example, whether an axial line has more connections and higher integration by virtue of its length or by virtue of a shorter distance between intersections. Thus, the interaction between the syntax of streets and the metric properties of blocks can pass unnoticed, or remain entangled with other variables.

From the broader point of view of linking measures of urban morphology to measures of space syntax, the work presented here is much more limited in ambition than the work recently presented by Berghauser-Pont and Marcus (2014) or Netto et al. (2012). These authors address the finer grain of physical form inside the block as well as the density of development in order to derive richer measures of patterns of accessibility. It would seem, however, that enriching the interface between classic space syntax measures and other morphological descriptors of urban form is a research aim which is being pursued with renewed intensity by many scholars in different centres of space syntax research.

The rest of this paper is organised as follows. First, we use design games to demonstrate that the patterns of differentiation of streets by integration that are of particular interest to space syntax can more easily arise in the presence of blocks of different sizes than when block size remains constant. Having demonstrated that there is a systematic link between the differentiation of streets by integration and the presence of blocks of different sizes, we then proceed to ask whether smaller blocks are associated with more integrated streets. We address this question by developing a new methodology to analyse a small sample of towns and villages in the Provence. We subsequently address the same question by analysing historic maps of the same towns. We show that blocks of small sizes are distributed around the street network and are not associated with streets of higher integration. This is true both at present and historically, even as, since the time of the first cadastral maps, the street layout of the towns was modified, leading to more clearly structured integration cores. The results of these analyses provide a foundation for a fresh discussion of some elementary generators of settlement form presented in *The Social Logic of Space* (Hillier and Hanson, 1984). Setting the properties of the analysed sample against the properties of 'beady ring' hamlets, we speculate about the fundamental logical transformations that may characterise the creation of the typical integration structures that have been called 'deformed wheels' (Hillier et al., 1983; Hillier, 1996).

Design games: How easy is it to differentiate streets by integration while keeping block size constant?

In this section, the French city of Apt is taken as an example, in order to demonstrate that the differentiation of block sizes is systematically linked to the syntactic differentiation of streets by integration. Apt (Figure 1) is chosen because it is known to space syntax scholars as an example of the 'deformed wheel integration core' evoked in early introductions to space syntax analysis (Hillier et al., 1983; Hillier et al., 1987). The expression refers to a urban layout where the main streets, those that serve to bring the parts together and provide access to visitors coming from the outside, extend from the inner area of the town to its perimeter in radiating 'spokes' and also make circumferential connections along the 'rim'.

As shown in Figure 1.2, the town has 45 blocks (including open public spaces surrounded by streets in the count), covers 11.6 hectares (inside the peripheral street centre line) and has about 5.5 kilometres of streets, forming 85 intersections between 139 street segments (130 if we exclude cul-de sacs and the bifurcation of an edge street in response to topography). Here we count nodes with more than two incident streets as 'intersections,' offering a genuine navigation choice. We define street segments as portions of streets connecting such intersections. Street segments can coincide with single line segments or encompass chains of multiple line segments. Figure 1.3 shows the angular integration core forming a cross through the middle of the town and encompassing portions of is periphery. Visual inspection immediately shows that we can distinguish between long main streets, radial or peripheral, and short infill streets. The former tend to be more integrated and be part of the integration core. Such distinction between the primary connecting spanning grid of cities and the

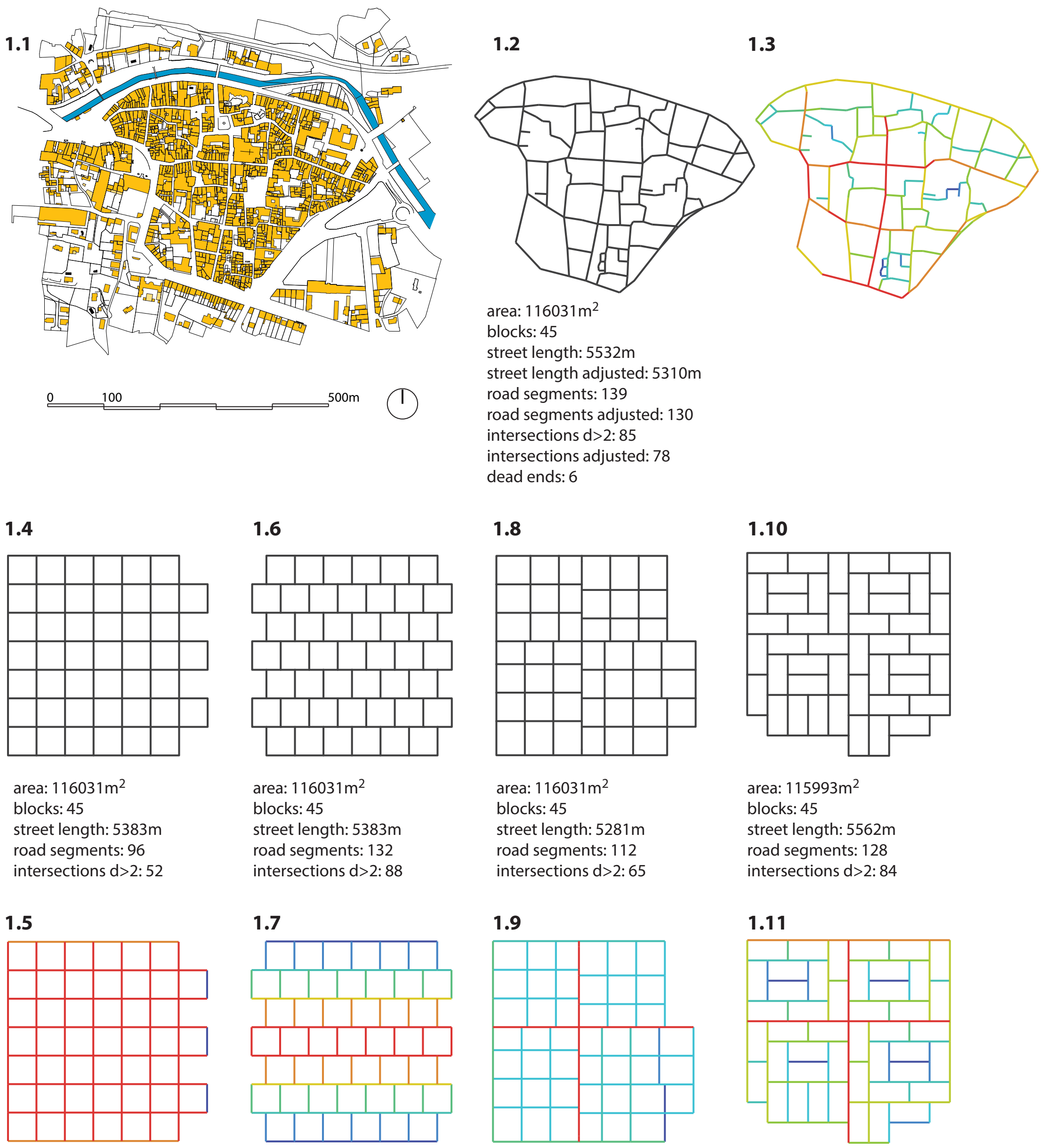


Figure 1:

Apt, analysis and theoretical transformations.

1.1: Cadastral map.

1.2: Street center line map. 'Adjusted' values exclude cul-de -sacs and links at the eastern edge which respond to local topography.

1.3: Apt, angular integration, no radius restriction.

1.4: Regular grid approximation to Apt.

1.5: Regular grid angular integration.

1.6: Offset grid approximation to Apt.

1.7: Offset grid angular integration.

1.8: Deformed grid approximation to Apt.

1.9: Deformed grid angular integration.

1.10: Nested pattern approximation to Apt.

1.11: Nested pattern angular integration.

secondary infill grid that makes up the local, mostly residential, areas is of fundamental significance to the syntactic understanding of the city (Hillier, 2002). We can also distinguish, however, between large and small urban blocks, distributed throughout the historic core of Apt. The question is whether these two kinds of differentiation interact, and how. Is the differentiation of block sizes an integral part of syntactic structure? Here the question is initially approached heuristically, by comparing the actual layout to hypothetical layouts which are equivalent to Apt, according to specific parameters.

Figure 1.4 shows the best approximation to a regular square grid (blocks 50.78 metres on the side), with the same area and number of blocks as Apt. The hypothetical city has comparable street length but fewer intersections and street segments. Quite clearly, the main difference between the hypothetical regular grid and Apt is the pattern of differentiation according to street length and integration which is present in Apt and absent in the hypothetical city. In the regular grid, most streets have equal connectivity, local and global, resulting in similar angular integration values (Figure 1.5).

Figure 1.6 shows another hypothetical grid with the same area and number of blocks as Apt, a very similar street length, and almost the same number of street segments – albeit with a larger number of intersections. The angular integration pattern (Figure 1.7) naturally exhibits diminishing values as we move from the middle to the edges along the direction of offset short streets. Values are constant along the other direction, the direction of continuous streets. Obviously, this pattern is not 'town-like'. It imposes a strong distinction between uninterrupted movement flows in one direction, and interrupted flows in the other. Apt embraces uninterrupted and interrupted movement in both directions.

Figure 1.8 is an attempt to create an orthogonal and reasonably regular system which shares with Apt the fundamental structure of crossing main streets, peripheral main streets, and shorter infill streets. Angular integration is shown in Figure 1.9. While the internal crossing main streets predominate, some of the edge streets are next in rank with high integration values. However, unlike the hypothetical designs 1.4 and 1.6, design 1.8 depends upon a variation of block sizes (only 18 blocks are of the standard size used in 1.4 and 1.6). This implies that 'Apt-like' properties can be fairly easily achieved if block sizes are allowed to vary. In this particular example, smaller blocks are consistently attached to the central crossing streets. Such clear association between small block size and proximity to a main street is not evident in Apt, at least not at first glance.

The design games presented above result in topologically equivalent patterns (same number of circulation rings defined by the same number of blocks) realised in equivalent land areas, but displaying a range of syntactic structures. One question raised, particularly with the last hypothetical example, is whether there can be a system with a standard block size and shape that tends to the syntax of Apt. Figure 1.10 shows such a system with standard blocks of proportion 1:2 (blocks are 35.9m x 71.8m). Figure 1.11 shows the pattern of angular integration. The 'trial and error' design game efforts, as well as intuition, suggest that the design shown in Figure 1.10 requires careful manipulation of rotations and adjacencies. It is much easier to obtain syntactic differentiation of a requisite kind by allowing block sizes to vary than by requiring that they be standardised. In other words, intuitive design games suggest that the link between block size and syntactic structure is systematic, not incidental.

In an often quoted pair of papers, Siksna (1997, 1998) reports that in large city centres, large blocks fragment as new streets are added, thus tending to optimal block sizes. Based on empirical evidence from a sample of eight US and Australian cities, he suggests that street intervals of 80-100 metres balance the needs of vehicular and pedestrian movement, while shorter intervals of 50-70 metres are appropriate for areas with intense pedestrian activity and retail uses. These optimalities account for the tendency for blocks which are larger than 20,000 square metres (141m x 141m) to fragment, particularly in the central areas of cities. Fragmentation increases the density of streets in the interests of higher street connectivity; it also increases the length of property frontages within a given area. Of course, in the case of a small historic city such as Apt, distances between intersections and block sizes are at the smaller end of Siksna's spectrum. Thus, it would be unwise to look at Apt through the lens of Siksna's work in a mechanistic way. In Apt, the average distance between intersections is 40.5 metres and the average block size is 2,578 square metres. Thus, the dynamics revealed by Siksna do not apply. The question can still be raised: given block size differentiation, is there any association between smaller blocks and syntactic centrality? A perusal of Figure 1.1 indicates that no consistent pattern is present.

There are good intuitive correlates of why block sizes might vary independent of syntactic centrality: on the one hand, smaller blocks imply greater length of frontage, a more intense interface between streets and buildings. Such affordance would make greater sense if associated with areas of high integration that are likely to attract higher densities of pedestrian movement. On the other hand, for the range of block sizes we have in Apt, the smaller blocks may preclude contemporary building types and building footprints that are otherwise desirable. Steadman (2014a), for example, shows that modern office buildings cannot be accommodated in blocks which are less than 60-65 metres on the side. The presence of such buildings in the more integrated and accessible parts of the city would be contingent on the presence of larger blocks. In the next section we present an analysis of five settlements, including Apt, to pursue the relation of syntactic structure to block size more systematically. The aim is to see whether the morphological forces that may bear on the relationship of block size to integration result in any statistically regular pattern.

Block size and angular integration in a small sample of towns and a village in the Provence

Five settlements were chosen for analysis: Aix-en-Provence, Apt, Avignon, Carpentras and Gassin. Gassin will be even more familiar to space syntax scholars as an example frequently featured in spatial analysis (for example, Batty, 2013), since it was first used as the primary convenient example in *The Social Logic of Space* (Hillier and Hanson, 1984). Apt, Avignon and Carpentras are located in the department of the Vaucluse, in the area of Provence, in the south of France, which also includes Aix-en-Provence and Gassin. The former is located in the department of Bouches-du-Rhône and the latter in the department of Var. This geographical area also includes the small hamlets and villages that serve as the basis for the description of the 'beady ring' settlement type and the development of early generative models of space syntax – a subject to which we will return later. The longest straight line distance between any two of the five settlements under consideration here is about 100 miles (from Gassin to Avignon), while Apt, Avignon and Carpentras are within one hour's drive from each other.

The quantitative profile of these settlements is offered in Table 1. The area ranges between 1.4 and 155.4 hectares. Total street length ranges between 1.7 and 46.5 kilometres and increases linearly with area (r^2=0.995, p<0.0002). The logarithm of the density of street length per hectare decreases with the logarithm of area (r^2=0.94, p<0.0062). Mean distance between intersections ranges between 24 and 54.7 metres and increases with the logarithm of area (r^2=0.97, p<0.0021). Mean block size ranges between 0.03 and 0.45 hectares and increases with the logarithm of area (r^2=0.97, p<0.0021). We note that public spaces fully surrounded by streets were

Variable	Aix-en-Provence	Apt	Avignon	Carpentras	Gassin
Area (ha)	69.1	11.6	155.4	23.6	1.4
Street length (km)	24.4	5.5	46.5	10.1	1.7
Street length/hectare (km)	0.35	0.48	0.30	0.43	1.23
Number of Street Segments	465	139	850	212	69
Mean distance between intersections (m)	52.4	39.8	54.7	47.5	24.0
Number of blocks	154	45	255	72	23
Mean block area (ha)	0.32	0.20	0.45	0.23	0.03
Total area inside the blocks	50.0	8.8	113.6	16.6	0.8
Proportion of settlement area inside the blocks	0.72	0.76	0.73	0.70	0.57

Table 1:

Numeric profile of five settlements, 2014 maps.

treated as blocks. At the same time, public spaces between streets and built volumes were not included in the blocks but 'conceded' to the streets. Thus, the proportion of space inside the blocks should not be equated with the proportion of space given to private properties. We computed more accurately the proportion of space given to streets and public spaces, and this is shown in Table 3, which is discussed later. Here we note that the proportion varies between 0.26 in Apt and 0.43 in Gassin.

The distribution of angular integration for the street centre line map of these towns is shown in Figure 2. With the exception of Gassin, where the most integrated street centre line segments form a skeleton with

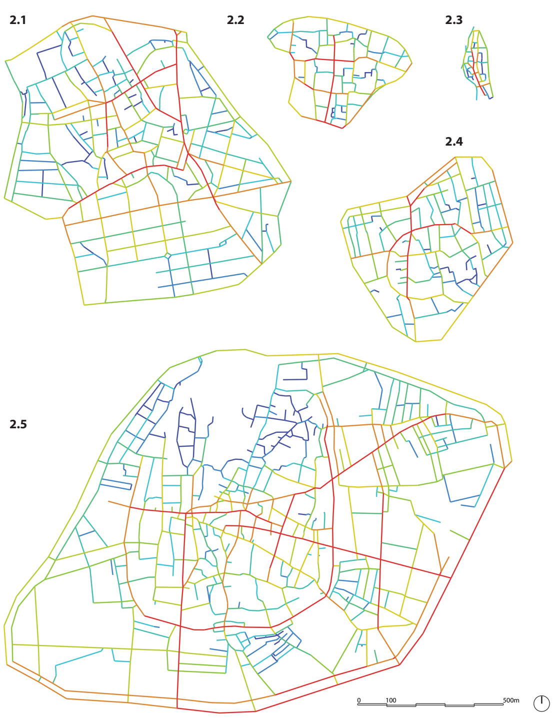


Figure 2 (left):

Angular integration, no radius restriction.

2.1: Aix-en-Provence.
2.2: Apt.
2.3: Gassin.
2.4: Carpentras.
2.5: Avignon.

The spectrum from high to low integration is mapped on the colour spectrum from red to blue, in 10 percentiles.

Figure 3 (right):

Blocks grouped in four percentiles by size, for each settlement separately. Darker shades are used for smaller blocks.

3.1: Aix-en-Provence
3.2: Apt
3.3: Gassin
3.4: Carpentras
3.5: Avignon.

Table 2 (1-2):

Relationship between block size and angular integration.

Table 2.1: Aix-en-Provence, 2014

Block Group	Blocks reached	Percentage of lines cumulatively considered, by angular integration percentiles									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1 (small)	**Number of blocks reached**	17	25	30	35	39	39	39	39	39	39
	As proportion of all blocks	11	16	20	23	25	25	25	25	25	25
	As proportion of blocks reached	35	28	26	27	27	26	25	25	25	25
G2	**Number of blocks reached**	12	22	28	33	37	37	38	38	39	39
	As proportion of all blocks	8	14	18	22	24	24	25	25	25	25
	As proportion of blocks reached	24	25	24	25	26	25	25	25	25	25
G3	**Number of blocks reached**	7	17	24	27	31	37	38	38	38	38
	As proportion of all blocks	5	11	16	18	20	24	25	25	25	25
	As proportion of blocks reached	14	19	21	20	22	25	25	25	25	25
G4 (large)	**Number of blocks reached**	13	25	33	37	37	37	38	38	38	38
	As proportion of all blocks	8	16	22	24	24	24	25	25	25	25
	As proportion of blocks reached	27	28	29	28	26	25	25	25	25	25
All groups	**Number of blocks reached**	49	89	115	132	144	150	153	153	154	154
	As proportion of all blocks	32	58	75	86	94	97	99	99	100	100

Table 2.2: Apt, 2014

Block Group	Blocks reached	Percentage of lines cumulatively considered, by angular integration percentiles									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1 (small)	**Number of blocks reached**	**3**	**4**	**5**	**8**	**9**	**10**	**12**	**12**	**12**	**12**
	As proportion of all blocks	7	9	11	18	20	22	27	27	27	27
	As proportion of blocks reached	20	14	14	20	21	23	27	27	27	27
G2	**Number of blocks reached**	**2**	**7**	**10**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
	As proportion of all blocks	4	16	22	24	24	24	24	24	24	24
	As proportion of blocks reached	13	24	28	27	26	26	24	24	24	24
G3	**Number of blocks reached**	**5**	**8**	**10**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
	As proportion of all blocks	11	18	22	24	24	24	24	24	24	24
	As proportion of blocks reached	33	28	28	27	26	26	24	24	24	24
G4 (large)	**Number of blocks reached**	**5**	**10**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
	As proportion of all blocks	11	22	24	24	24	24	24	24	24	24
	As proportion of blocks reached	33	34	31	27	26	26	24	24	24	24
All groups	**Number of blocks reached**	**15**	**29**	**36**	**41**	**42**	**43**	**45**	**45**	**45**	**45**
	As proportion of all blocks	33	64	80	91	93	96	100	100	100	100

Table 2 (3-4):

Relationship between block size and angular integration.

Table 2.3: Avignon, 2014											
Block Group	**Blocks reached**	**Percentage of lines cumulatively considered, by angular integration percentiles**									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1 (small)	**Number of blocks reached**	**30**	**38**	**43**	**49**	**51**	**57**	**59**	**63**	**63**	**64**
	As proportion of all blocks	12	15	17	19	20	22	23	25	25	25
	As proportion of blocks reached	27	26	24	25	24	25	25	25	25	25
G2	**Number of blocks reached**	**25**	**35**	**44**	**45**	**48**	**56**	**57**	**61**	**64**	**64**
	As proportion of all blocks	10	14	17	18	19	22	22	24	25	25
	As proportion of blocks reached	23	23	25	23	23	24	24	24	25	25
G3	**Number of blocks reached**	**22**	**30**	**39**	**45**	**51**	**57**	**58**	**62**	**62**	**64**
	As proportion of all blocks	9	12	15	18	20	22	23	24	24	25
	As proportion of blocks reached	20	20	22	23	24	25	25	25	25	25
G4 (large)	**Number of blocks reached**	**33**	**46**	**52**	**57**	**62**	**62**	**62**	**63**	**63**	**63**
	As proportion of all blocks	13	18	20	22	24	24	24	25	25	25
	As proportion of blocks reached	30	31	29	29	29	27	26	25	25	25
All groups	**Number of blocks reached**	**110**	**149**	**178**	**196**	**212**	**232**	**236**	**249**	**252**	**255**
	As proportion of all blocks	43	58	70	77	83	91	93	98	99	100

Table 2.4: Carpentras, 2014											
Block Group	**Blocks reached**	**Percentage of lines cumulatively considered, by angular integration percentiles**									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1 (small)	**Number of blocks reached**	**3**	**9**	**12**	**14**	**16**	**16**	**17**	**17**	**18**	**18**
	As proportion of all blocks	4	13	17	19	22	22	24	24	25	25
	As proportion of blocks reached	14	21	21	22	24	23	24	24	25	25
G2	**Number of blocks reached**	**4**	**9**	**12**	**14**	**16**	**18**	**18**	**18**	**18**	**18**
	As proportion of all blocks	6	13	17	19	22	25	25	25	25	25
	As proportion of blocks reached	19	21	21	22	24	26	25	25	25	25
G3	**Number of blocks reached**	**9**	**14**	**15**	**17**	**18**	**18**	**18**	**18**	**18**	**18**
	As proportion of all blocks	13	19	21	24	25	25	25	25	25	25
	As proportion of blocks reached	43	33	26	27	26	26	25	25	25	25
G4 (large)	**Number of blocks reached**	**5**	**11**	**18**	**18**	**18**	**18**	**18**	**18**	**18**	**18**
	As proportion of all blocks	7	15	25	25	25	25	25	25	25	25
	As proportion of blocks reached	24	26	32	29	26	26	25	25	25	25
All groups	**Number of blocks reached**	**21**	**43**	**57**	**63**	**68**	**70**	**71**	**71**	**72**	**72**
	As proportion of all blocks	29	60	79	88	94	97	99	99	100	100

Table 2 (5):

Relationship between block size and angular integration.

Table 2.5: Gassin, 2014											
Block Group	**Blocks reached**	**Percentage of lines cumulatively considered, by angular integration percentiles**									
		10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
G1 (small)	**Number of blocks reached**	**1**	**2**	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
	As proportion of all blocks	4	9	22	26	26	26	26	26	26	26
	As proportion of blocks reached	10	14	24	26	26	26	26	26	26	26
G2	**Number of blocks reached**	**4**	**5**	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
	As proportion of all blocks	17	22	22	26	26	26	26	26	26	26
	As proportion of all blocks	40	36	24	26	26	26	26	26	26	26
G3	**Number of blocks reached**	**2**	**3**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
	As proportion of all blocks	9	13	26	26	26	26	26	26	26	26
	As proportion of blocks reached	20	21	29	26	26	26	26	26	26	26
G4 (large)	**Number of blocks reached**	**3**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	As proportion of all blocks	13	17	22	22	22	22	22	22	22	22
	As proportion of blocks reached	30	29	24	22	22	22	22	22	22	22
All groups	**Number of blocks reached**	**10**	**14**	**21**	**23**	**23**	**23**	**23**	**23**	**23**	**23**
	As proportion of all blocks	43	61	91	100	100	100	100	100	100	100

branches inside the village, the pattern of integration for street line segments analysis approximates a deformed wheel to varying degrees, with the inclusion of some edge streets as well as traversing radials.

In order to analyse the distribution of block sizes, the following method was developed. First, all blocks were classified into four quantiles by size. The maps of the towns with the classification of blocks are shown in Figure 3. In turn, street centre lines were classified in 10 percentiles according to angular integration. The distribution of block sizes relative to integration was then mapped as follows: we first identified the set of blocks with an edge that is tangent to a line segment belonging to the first percentile; we subsequently proceeded in cumulative steps, adding the newly reached blocks for each successive percentile of line segments. In this way we were able to measure the number and overall proportion of blocks newly reached for each percentile of line segments. These were sorted into subsets that corresponded to each of the four size-based groups of blocks. The results of the analysis are summarised in Table 2. A visual demonstration of the method, using Apt as the example, is offered in Figure 4.

Based on the data in Table 2, we developed graphs representing the distributions of blocks reached by block groups and cumulative line percentiles, as shown in Figure 5. These capture the proportion of the total number of blocks in each block-size group captured by each successive centre-lines percentile (left column); and also the proportion of the blocks captured that belongs to each block-size group (right column). As shown in Figure 5, there is no tendency for smaller blocks to be tangent on the most integrated line segments. In the cases of Apt, Carpentras and Gassin, the opposite is the case: one has to reach less integrated line segments before capturing smaller blocks. In the case of Avignon and Aix-en-Provence, small blocks are captured at roughly the same rate as larger blocks. Only in one case, that of Aix-en-Provence, can we say there is a slight tendency for smaller blocks to be captured at a faster rate (by more integrated lines) than larger blocks.

We conclude that the analysis of the five settlements does not support the hypothesis that more integrated lines are systematically associated with smaller blocks. The general tendency is for blocks of different sizes to be tangent to lines across the spectrum of integration values. From the point of view of building footprints, this implies some locational flexibility: larger and smaller buildings can become associated with different degrees of street integration.

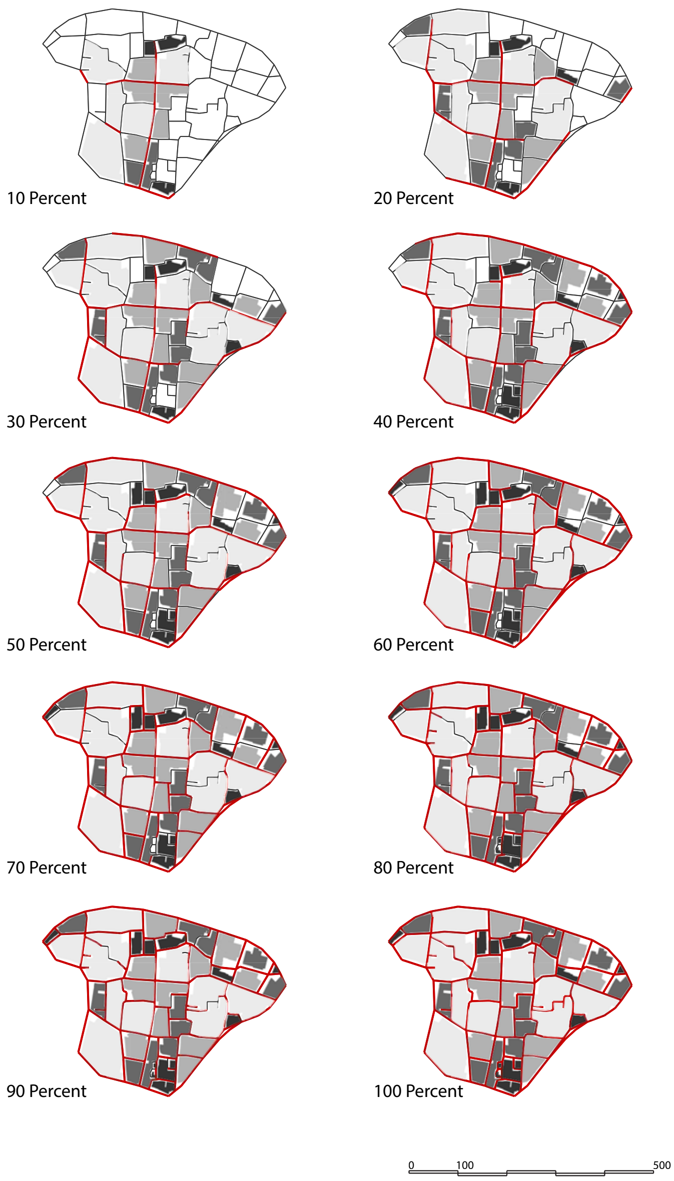


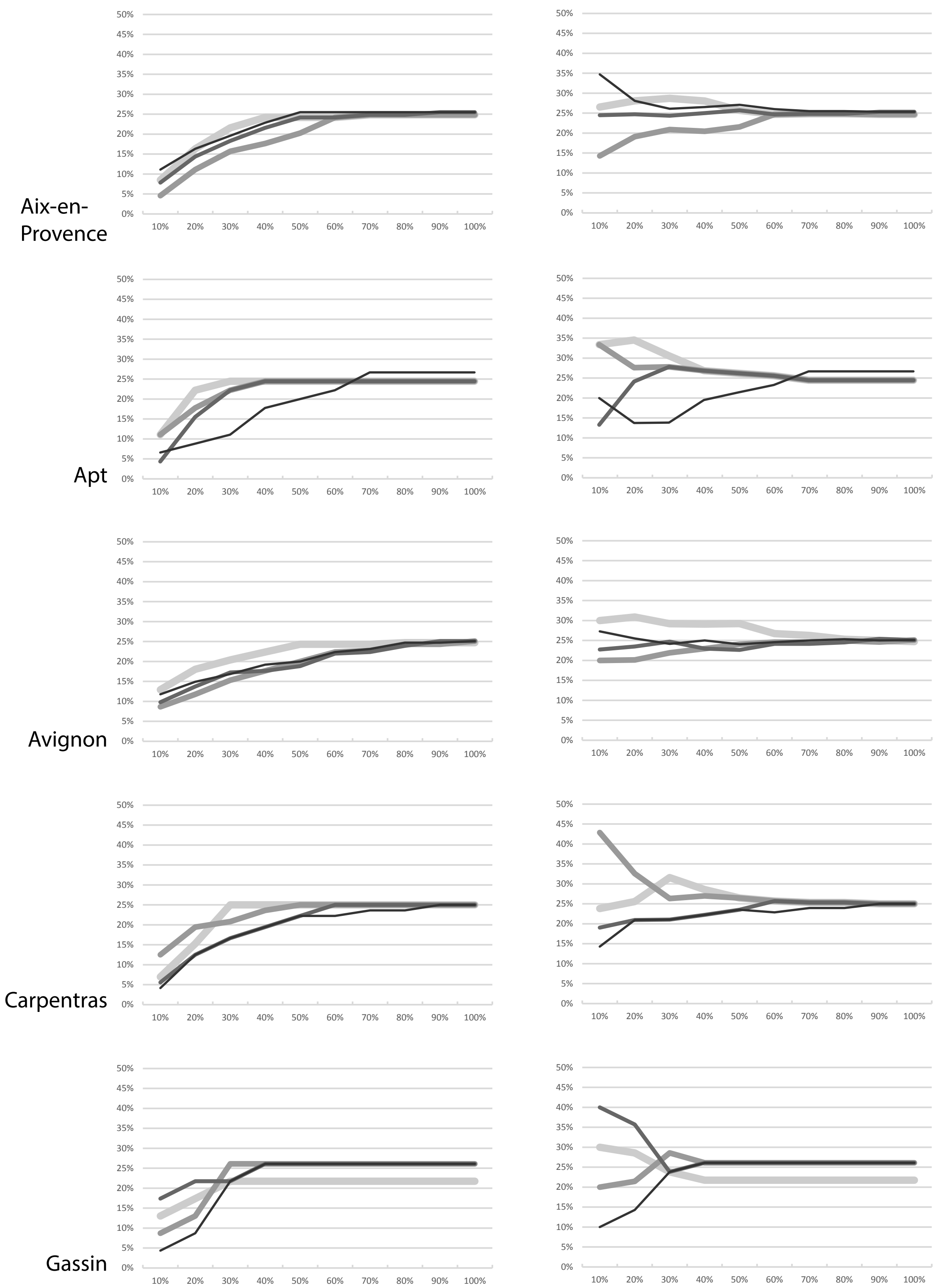
Figure 4:

The methodology used to analyse the relationship between angular integration and block size. Lines are sorted in 10 percentiles based on angular integration values. Blocks are sorted in 4 quantiles based on size – darker shades are used for smaller blocks. The blocks in each of the four groups, reached by cumulatively considering each successive line percentile are recorded in order to study the relationship between street integration and block size.

Figure 5:

Analysis of the distribution of block size by street center line angular integration.

Blocks are sorted into four groups by size; darker shades indicate smaller blocks. Line segments are sorted into 10 percentiles by angular integration. The graphs show the proportions of blocks in each size group that are captured at cumulative line percentile intervals. The left column expresses the blocks reached for each group as a proportion of the total number of blocks present in the settlement. The right column expresses the blocks reached in each group as a proportion of all the all blocks reached at the particular cumulative percentile interval.



From the point of view of street connectivity, the intermingling of smaller and larger blocks implies a variation of the distance between intersections. This, in turn, produces a variation in the street length which is accessible from any given street segment, within a radius of walking network distance. In Figure 6 we present the distribution of metric reach at a 100-metre radius. Metric reach is simply the total street length accessible within a specified network distance (Peponis et al., 2008). The radius chosen here is restricted enough to be sensitive to the pattern of local connectivity as this is affected by block size; but not only by block size, since metric reach reflects the way in which the streets surrounding the blocks are weaved into a network. The village of Gassin is so small that the distribution of metric reach for a 100-metre radius essentially reflects the transition from the middle of the settlement to the edge, in a concentric pattern. In the four towns, the distribution picks up multiple locations where the density of the street network is intensified. These locations are distributed across the area of the towns. Furthermore, the street segments with higher metric reach sometimes coincide with those of high angular integration (Figure 3), but very often they do not. We see an interplay rather than a coincidence between the distribution of spaces that afford access to a denser local street system, and the distribution of spaces that act as a primary skeleton for the whole network by virtue of affording connections to all parts through a minimum aggregate angle of direction changes. Results look different for each parametric modification of the radius for which metric reach is calculated (say for 80 or 120 metres as compared to 100) but the underlying dynamic is the same while the radius is small. From the point of view of angular integration, the towns appear as interfaces between a global skeleton of main streets, and other streets attached to the skeleton or inserted in its interstices. From the point of view of metric reach for a small radius (no more than two or three multiples of the mean distance between intersections), the towns appear as street networks with multiple embedded nuclei of higher street density.

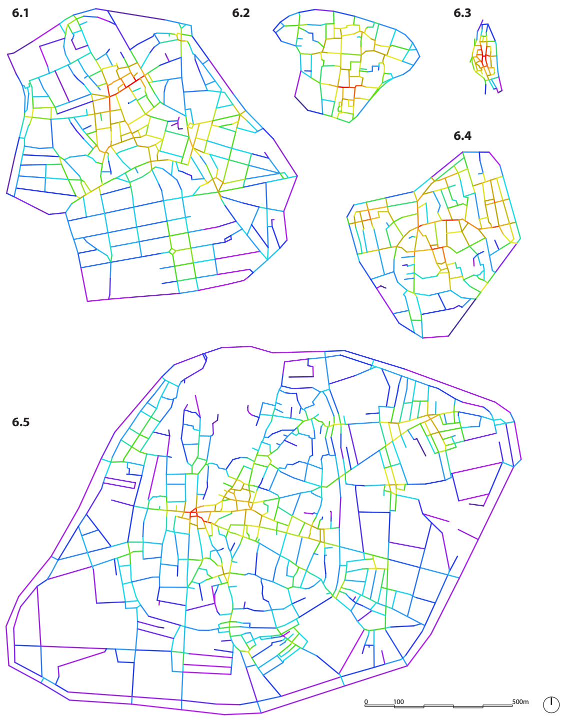


Figure 6:

Length of street accessible within a 100 meters from the center of each line segment (metric reach at 100 meters radius). The spectrum from high to lower values is mapped on the colour spectrum from red to blue.

6.1: Aix-en-Provence
6.2: Apt
6.3: Gassin
6.4: Carpentras
6.5: Avignon.

Changes in spatial structure: Comparing nineteenth century cadastral maps to the present condition

Would the same patterns of mixture of block sizes for each percentile of street integration be found in earlier maps of these towns? To answer this question we compare the earliest available (Napoleonic) cadastral maps of the five settlements to their present condition. Figures 7-11 provide visual comparisons of the earliest and the current maps. They also highlight parts of blocks removed in order to create or enlarge streets, and parts added. Table 3 summarises the spatial evolution in numerical profiles. In the case of Aix-en-Provence, transformations are

Figure 7:

Aix-en-Provence 1828 - 2014.

7.1: Aix-en-Provence,1828.

7.2: Aix-en-Provence, 2014.

7.3: Parts of blocks removed in the transformation from 1828 - 2014.

7.4: Parts of blocks added in the transformation from 1828 – 2014.

minimal. A regular plan was already present in the seventeenth century through the extension of the town by a regular grid under Cardinal Mazarin. In all other cases transformations are significant. In 1821, Apt had only one traversing main-street, in the east-west direction; the main north-south internal street emerged later. Public squares were added. In Avignon, new major streets are added linking the centre to the east and south edges; there are additional new streets as well as several cases of street-widening. In Carpentras the main change is the creation of public squares. Gassin evolved with the addition of new urban blocks, some at the edge and some inside the village.

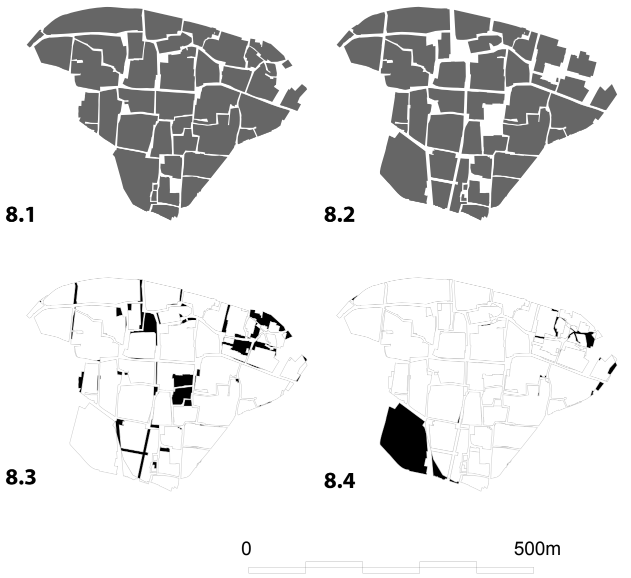


Figure 8:

Apt 1821 – 2014.

8.1: Apt,1821.

8.2: Apt, 2014.

8.3: Parts of blocks removed in the transformation from 1821 - 2014.

8.4: Parts of blocks added in the transformation from 1821 - 2014.

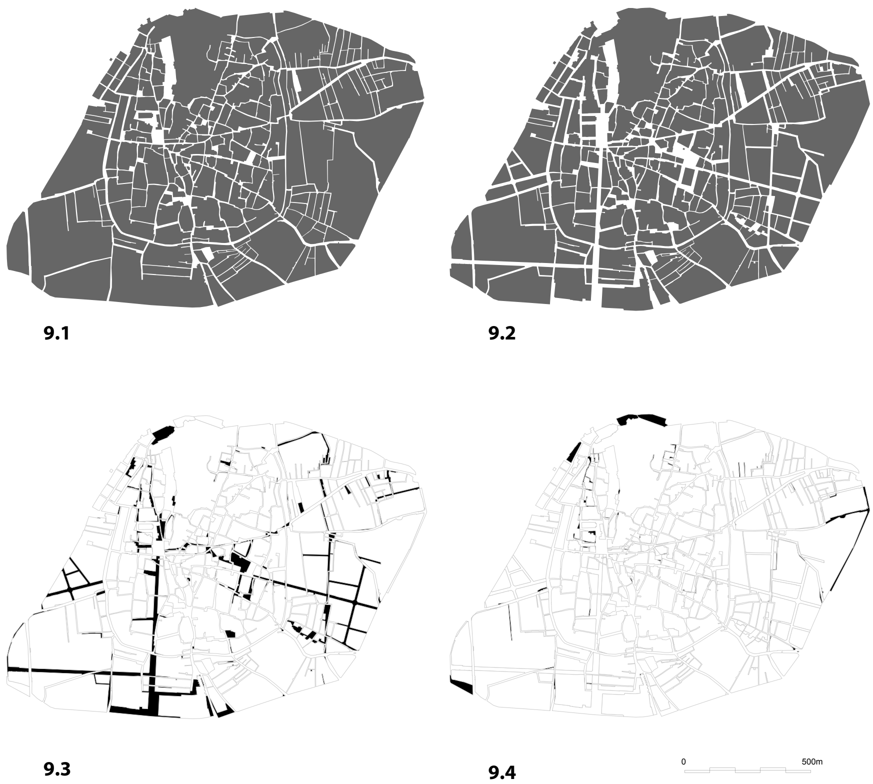


Figure 9:

Avignon 1820 – 2014.

9.1: Avignon, 1820.

9.2: Avignon, 2014.

9.3: Parts of blocks removed in the transformation from 1820 - 2014.

9.4: Parts of blocks added in the transformation from 1820 - 2014.

Figure 10:

Carpentras 1834 – 2014.

10.1: Carpentras, 1834.

10.2: Carpentras, 2014.

10.3 Parts of blocks removed in the transformation from 1834 - 2014.

10.4: Parts of blocks added in the transformation from 1834 - 2014.

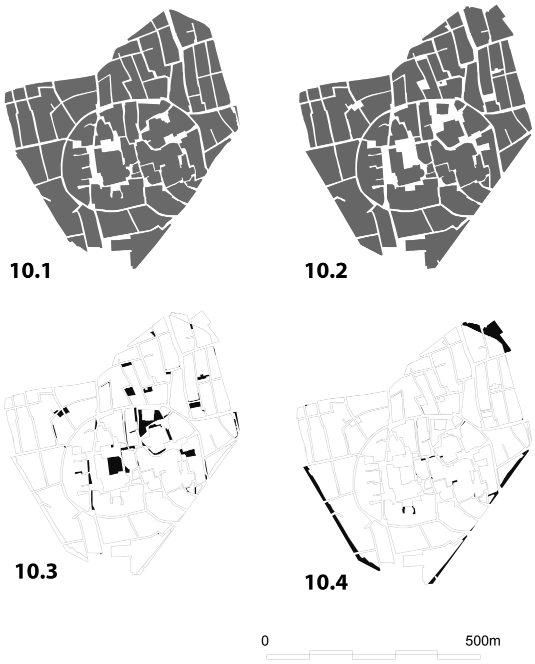


Figure 11:

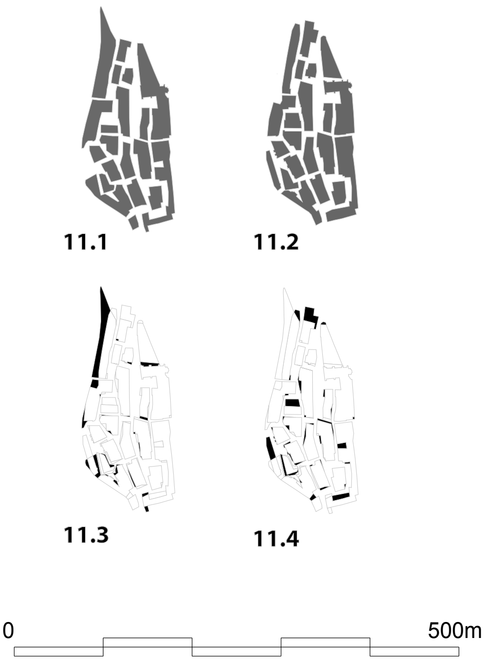
Gassin 1808 – 2014.

11.1: Gassin, 1808.

11.2: Gassin, 2014.

11.3 Parts of blocks removed in the transformation from 1808 - 2014.

11.4: Parts of blocks added in the transformation from 1808 - 2014.



The evolution summarised in Table 3 entails the following. First, the area of the towns increased, at least in some cases. The rate of increase is almost 20% in Carpentras and 10% in Apt, mostly as a result of the demolition of the walls. Second, the amount of public space increased in all cases, by between 7% and 43%. This increase is not due only to the addition of peripheral streets or sections of streets, but also to the widening of previously existing streets, the addition of new streets in the interior of the towns, and the creation of public squares. Nevertheless, street length per hectare did not change significantly. Metric reach at a 100-metre walking radius increased in all cases, implying reduced distances between intersections. The average linear extension of streets increased in all cases but Aix-en-Provence, which was endowed with an early grid plan, as we have seen. Certain main streets became better aligned as shown by visual perusal of the maps. The average proportion of street length accessible within two direction changes increased in all cases but Aix-en-Provence. This implies that cities evolved to more grid-like structures. The mean directional distance, taking 20 degrees as the threshold for counting a direction change, decreased in all cases.

The distribution of block size relative to angular integration was analysed using the method described above. Table 4 shows the numerical data. The graphs representing the distributions of blocks reached by block groups and cumulative line percentiles are shown in Figure 12. With the exception of Aix-en-Provence, the proportion of small blocks captured by successive integration percentiles trails behind the proportion of larger blocks. The conclusion reached by the analysis of the present condition is, therefore, extended by the analysis of the nineteenth century condition. There is no association between small blocks and angular integration.

	Aix-en-Provence 1829	Aix-en-Provence 2014	Apt 1821	Apt 2014	Avi-gnon 1820	Avignon 2014	Carpentras 1834	Carpentras 2014	Gassin 1808	Gassin 2014
Area (ha)	67.8	69.1 (0.02)	10.57	11.6 (0.10)	155	155.4 (0.003)	19.91	23.6 (0.19)	1.15	1.35 (0.17)
Number of blocks	155	154	41	45	226	255	56	72	20	23
Sum block area (ha)	49.46	49.23	8.59	8.58	120.82	112.65	15.75	16.49	0.70	0.77
Proportion of public space	0.27	0.29 (0.07)	0.19	0.26 (0.37)	0.22	0.28 (0.27)	0.21	0.30 (0.43)	0.39	0.43 (0.10)
Street Length (km)	24.59	24.4	4.86	5.5	43.07	46.49	8.47	10.07	1.37	1.66
Street Length per Hectare (km)	0.36	0.35	0.46	0.47	0.28	0.30	0.43	0.43	1.19	1.23
Metric Reach 100 m (m)	497.80	505.56	547.61	570.82	456	466	493.89	525.59	777.760	858.19
Linear extension (m)	237.67	207.96	104.75	169.27	361	369	145.64	158.41	76.51	94.97
Mean 2 direction changes reach / street length	0.185	0.183 (0.01)	0.178	0.342 (0.92)	0.095	0.134 (0.41)	0.202	0.227 (0.12)	0.349	0.481 (0.37)
Mean Directional Distance	3.99	3.98 (0.002)	4.55	3.08 (0.32)	5.36	4.92 (0.08)	3.95	3.63 (0.08)	3.237	2.58 (0.20)

Table 3:

An outline of changes from the early 19th century to the present in five settlements.

Table 4.1: Aix-en-Provence, 1829

Block Group	Blocks reached	Percentage of lines cumulatively considered, by angular integration percentiles									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1 (small)	**Number of blocks reached**	**17**	**26**	**29**	**29**	**34**	**35**	**37**	**39**	**39**	**39**
	As proportion of all blocks	11	17	19	19	22	23	24	25	25	25
	As proportion of blocks reached	29	27	24	23	23	23	24	25	25	25
G2	**Number of blocks reached**	**13**	**22**	**29**	**33**	**37**	**38**	**38**	**38**	**39**	**39**
	As proportion of all blocks	8	14	19	21	24	25	25	25	25	25
	As proportion of blocks reached	22	23	24	26	25	25	25	25	25	25
G3	**Number of blocks reached**	**7**	**16**	**27**	**30**	**39**	**39**	**39**	**39**	**39**	**39**
	As proportion of all blocks	5	10	17	19	25	25	25	25	25	25
	As proportion of blocks reached	12	17	23	24	27	26	26	25	25	25
G4 (large)	**Number of blocks reached**	**21**	**31**	**35**	**35**	**36**	**38**	**38**	**38**	**38**	**38**
	As proportion of all blocks	14	20	23	23	23	25	25	25	25	25
	As proportion of blocks reached	36	33	29	28	25	25	25	25	25	25
All groups	**Number of blocks reached**	**58**	**95**	**120**	**127**	**146**	**150**	**152**	**154**	**155**	**155**
	As proportion of all blocks	37	61	77	82	94	97	98	99	100	100

Table 4 (1):

Relationship between block size and angular integration in the 19th century.

Table 4 (2-3):

Relationship between block size and angular integration in the 19th century.

Table 4.2: Apt, 1821

Block Group	Blocks reached	Percentage of lines cumulatively considered, by angular integration percentiles									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1	**Number of blocks reached**	**2**	**3**	**5**	**7**	**7**	**7**	**9**	**9**	**9**	**11**
(small)	As proportion of all blocks	5	7	12	17	17	17	22	22	22	27
	As proportion of blocks reached	13	17	19	21	21	20	23	23	23	27
G2	**Number of blocks reached**	**2**	**3**	**5**	**7**	**7**	**8**	**10**	**10**	**10**	**10**
	As proportion of all blocks	5	7	12	17	17	20	24	24	24	24
	As proportion of blocks reached	13	17	19	21	21	23	26	26	26	24
G3	**Number of blocks reached**	**6**	**6**	**9**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
	As proportion of all blocks	15	15	22	24	24	24	24	24	24	24
	As proportion of blocks reached	38	33	35	29	29	29	26	26	26	24
G4	**Number of blocks reached**	**6**	**6**	**7**	**10**	**10**	**10**	**10**	**10**	**10**	**10**
(large)	As proportion of all blocks	15	15	17	24	24	24	24	24	24	24
	As proportion of blocks reached	38	33	27	29	29	29	26	26	26	24
All	**Number of blocks reached**	**16**	**18**	**26**	**34**	**34**	**35**	**39**	**39**	**39**	**41**
groups	As proportion of all blocks	39	44	63	83	83	85	95	95	95	100

Table 4.3: Avignon, 1820

Block Group	Blocks reached	Percentage of lines cumulatively considered, by angular integration percentiles									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
G1	**Number of blocks reached**	**18**	**27**	**33**	**37**	**47**	**52**	**53**	**56**	**56**	**57**
(small)	As proportion of all blocks	8	12	15	16	21	23	23	25	25	25
	As proportion of blocks reached	21	21	22	21	24	25	24	25	25	25
G2	**Number of blocks reached**	**22**	**28**	**35**	**42**	**48**	**52**	**56**	**56**	**57**	**57**
	As proportion of all blocks	10	12	15	19	21	23	25	25	25	25
	As proportion of blocks reached	26	22	23	24	24	25	26	25	25	25
G3	**Number of blocks reached**	**17**	**28**	**33**	**41**	**50**	**52**	**54**	**56**	**56**	**56**
	As proportion of all blocks	8	12	15	18	22	23	24	25	25	25
	As proportion of blocks reached	20	22	22	23	25	25	25	25	25	25
G4	**Number of blocks reached**	**27**	**44**	**51**	**55**	**55**	**55**	**56**	**56**	**56**	**56**
(large)	As proportion of all blocks	12	19	23	24	24	24	25	25	25	25
	As proportion of blocks reached	32	35	34	31	28	26	26	25	25	25
All	**Number of blocks reached**	**84**	**127**	**152**	**175**	**200**	**211**	**219**	**224**	**225**	**226**
groups	As proportion of all blocks	37	56	67	77	88	93	97	99	100	100

Table 4 (4-5):

Relationship between block size and angular integration in the 19th century.

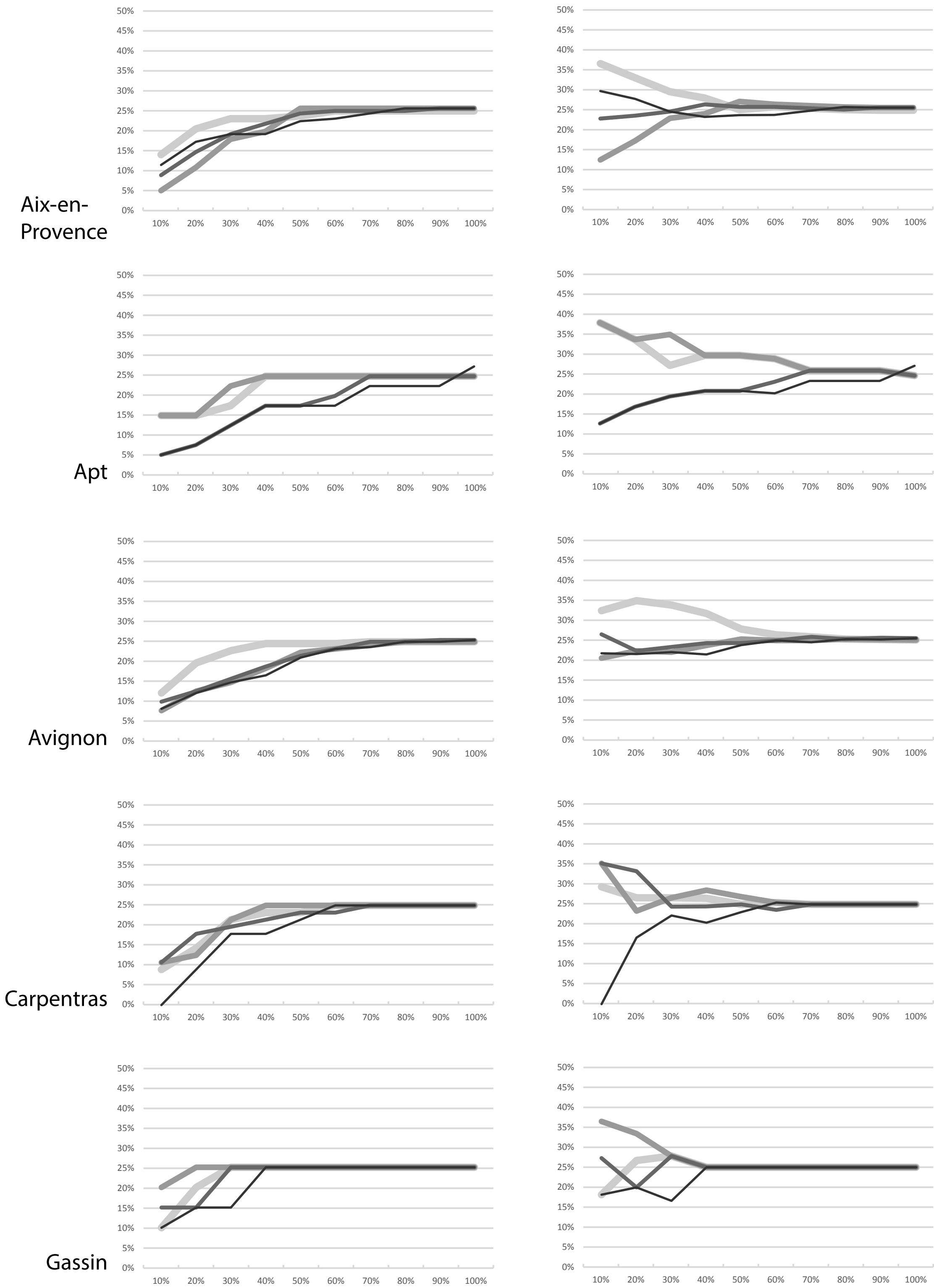
Table 4.4: Carpentras, 1834											
Block Group	**Blocks reached**	**Percentage of lines cumulatively considered, by angular integration percentiles**									
		10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
G1 (small)	**Number of blocks reached**	**0**	**5**	**10**	**10**	**12**	**14**	**14**	**14**	**14**	**14**
	As proportion of all blocks	0	9	18	18	21	25	25	25	25	25
	As proportion of blocks reached	0	17	22	20	23	25	25	25	25	25
G2	**Number of blocks reached**	**6**	**10**	**11**	**12**	**13**	**13**	**14**	**14**	**14**	**14**
	As proportion of all blocks	11	18	20	21	23	23	25	25	25	25
	As proportion of blocks reached	35	33	24	24	25	24	25	25	25	25
G3	**Number of blocks reached**	**6**	**7**	**12**	**14**	**14**	**14**	**14**	**14**	**14**	**14**
	As proportion of all blocks	11	13	21	25	25	25	25	25	25	25
	As proportion of blocks reached	35	23	27	29	27	25	25	25	25	25
G4 (large)	**Number of blocks reached**	**5**	**8**	**12**	**13**	**13**	**14**	**14**	**14**	**14**	**14**
	As proportion of all blocks	9	14	21	23	23	25	25	25	25	25
	As proportion of blocks reached	29	27	27	27	25	25	25	25	25	25
All groups	**Number of blocks reached**	**17**	**30**	**45**	**49**	**52**	**55**	**56**	**56**	**56**	**56**
	As proportion of all blocks	30	54	80	88	93	98	100	100	100	100

Table 4.5: Gassin, 1808											
Block Group	**Blocks reached**	**Percentage of lines cumulatively considered, by angular integration percentiles**									
		10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
G1 (small)	**Number of blocks reached**	**2**	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	As proportion of all blocks	10	15	15	25	25	25	25	25	25	25
	As proportion of blocks reached	18	20	17	25	25	25	25	25	25	25
G2	**Number of blocks reached**	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	As proportion of all blocks	15	15	25	25	25	25	25	25	25	25
	As proportion of blocks reached	27	20	28	25	25	25	25	25	25	25
G3	**Number of blocks reached**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	As proportion of all blocks	20	25	25	25	25	25	25	25	25	25
	As proportion of blocks reached	36	33	28	25	25	25	25	25	25	25
G4 (large)	N**umber of blocks reached**	**2**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
	As proportion of all blocks	10	20	25	25	25	25	25	25	25	25
	As proportion of blocks reached	18	27	28	25	25	25	25	25	25	25
All groups	**Number of blocks reached**	**11**	**15**	**18**	**20**	**20**	**20**	**20**	**20**	**20**	**20**
	As proportion of all blocks	55	75	90	100	100	100	100	100	100	100

Figure 12:

Analysis of the distribution of block size by street center line angular integration, 19th century maps.

Blocks are sorted into four groups by size; darker shades indicate smaller blocks. Line segments are sorted into 10 percentiles by angular integration. The graphs show the proportions of blocks in each size group that are captured at cumulative line percentile intervals. The left column expresses the blocks reached for each group as a proportion of the total number of blocks present in the settlement. The right column expresses the blocks reached in each group as a proportion of all the all blocks reached at the particular cumulative percentile interval.



From a space syntax point of view the main transformation between the two periods is the greater linear alignment of previously offset streets, the addition of new streets and the linear extension or the widening of streets. These transformations contribute to redefining or consolidating the primary connecting network. Changes in block shape and size are, of course, entailed in these transformations. These are picked up in the parts of Figures 7-11 which highlight block areas removed and block areas added between the nineteenth century and the present. But, the primary process occuring cannot be described in terms of a systematic linear relationship of block sizes to integration. Both historic periods studied are characterised by the distribution of blocks of varying sizes across the ranges of available integration.

How do blocks and streets interact? A speculation regarding the transition from aggregation to alignment

In this section we reflect on some possible formal determinants underlying the syntactic conditions described above. We start from the distinction between the third and seventh elementary generators discussed in *The Social Logic of Space* (Hillier and Hanson, 1984). The third generator describes a process of aggregation whereby each next building unit is attached to a growing clump of similar units. The units are composite, including paired enclosed and open elements. The attachment is defined as a face-to-face joint between either the two enclosed or the two open elements of a pre-existing unit and a newly added one. All else is left to randomness, except that 'free standing' 'corner-to-corner' joints between the solid portions are disallowed. Corner-to-corner joints are allowed to arise as a by-product of two units successively becoming attached via their enclosed elements to adjoining sides of the enclosed element of the same pre-existing unit. The patterns resulting from the third generator are characterised as 'beady rings.' The process results in building blocks of unequal size and variable shapes, leaving between them interlocking 'rings' of open space with narrower and wider parts. The edges of open spaces do not tend to have the alignment we typically associate with streets.

The seventh generator describes the creation of a street network by the arrangement of building blocks in proximity, so that blocks further out surround those further in, and so that interlocking rings of streets are created between the blocks. With this generator, each street segment is contained between two blocks. No direct contact between blocks is allowed.

Both generators produce an emergent network of interlocking rings of 'shared' open space that guarantees access to the building units. The subtle differences are twofold: the seventh generator assumes the 'building block' as a composite unit comprising many elementary units, all attached to the perimeter so as to be accessible from streets; by contrast, with the third generator, compound built forms emerge from the disposition of primary units. The seventh generator also evokes the more complex syntactic relationship of 'between'. By contrast, the third evokes the simpler idea of 'adjacency'. For the third generator, 'betweenness' is an emergent property. In short, the seventh generator can be treated as a rationalisation of the consequences of the third, a result of 'description retrieval'.

One could extend the argument further. As streets become linear, with strings of street segments being experienced as one longer street, so we see large groups of building blocks equally participating in containing the linearly extended street between them. Block faces become perfectly or imperfectly aligned to define street edges. Thus, the linear extension of streets could be seen as a further step in rationalisation, or description retrieval, within the process set in motion by the seventh generator. When all streets are similarly extended and aligned by major direction, then we have the emergence of the more or less regular grid.

The regular grid, however, might not be properly described by the seventh generator of Hillier and Hanson. It can more effectively be conceived as a grid of linear open spaces arranged to define a set of building blocks distributively contained by them. This 'global to local' conception of a street grid is paramount in urban design practice since Hippodamus (Aristotle, Politics, II-8). It appears to invert the syntactic function of the open and closed units in creating the relationship of betweenness. Our aim here, however, is not to suggest modifications of the list of primary syntactic generators, but rather to set a conceptual background on the basis of which we can think more systematically about the phenomena described in the previous section. The settlements under consideration could be seen as consequences of the deployment of the seventh generator, retaining elements of the third. This would account for the interspacing of blocks of different sizes, the presence of linearly extended streets requiring the alignment of many blocks and the presence of shorter streets contained between fewer blocks. The critical syntactic 'move' that gives the settlements under consideration their identity is the ***alignment*** of blocks to create longer streets, not the arrangement of block sizes according to the emerging structure of integration. This is highlighted by the historic comparison presented in the previous section. Siksna-like processes of block subdivision do not seem systematically relevant here, because the blocks tend to be small to start with.

To explore these ideas further, we look at a cluster of 'beady ring' hamlets. Figure 13 shows six such hamlets about 4.5 miles northwest of Apt, in the area of the Vaucluse. Of these, two are included in the examples used in *The Social Logic of Space* (Hillier and Hanson, 1984): Les Redons and Les Bellots. In Figure 13.7 we add the roads to the representation of the set of hamlets, and in Figure 13.8 we further add the parcels. One robust simplification that Hillier and Hanson allowed themselves is to only consider the built elements. For the purposes of our argument, it is important to also consider the ambient road pattern, as well as acknowledge the presence of property boundaries. The least consequence of adding the roads and the parcels is that the set of 'beady rings' now appears as an integral syntactic system rather than as a collection of individual hamlets only.

We computed metric reach at a 100-metre radius, angular integration, and directional distance with a 20-degree threshold for this system, as shown in Figure 14. First, five out of six hamlets are identified as nodes of higher reach (the exception is Les Blanchards). Second, none of the hamlets are traversed by a line of high angular integration, while five are proximate to one of them (the exception is Les Blanchards). Only one (Les Allemands) is adjacent to such a line. Lines of high integration are directly incident on Les Redons, but they are separated by a line of lesser integration. Third, when we consider directional distances (which differ from integration in that all direction changes above the threshold angle of 20-degree are treated as equivalent), the pattern is clarified. All hamlets are reached, but not traversed, by lines associated by lower mean directional distances. In short, the system of hamlets can be characterised as a set of nodes of path density linked but not traversed by a skeleton of paths with low directional distance. It is also worth noting that the skeleton of paths does not create direct links between the hamlets. The mean straight line distance between all pairs of hamlets is about 700 metres while the mean network distance is about 970 metres, an almost 40% increase over straight line distance. Figure 15.1 shows the road network used to make the minimum distance connections as well as the shortest distance lines.

We then inquired how many of the hamlets could fit inside the boundary of previously analysed settle-

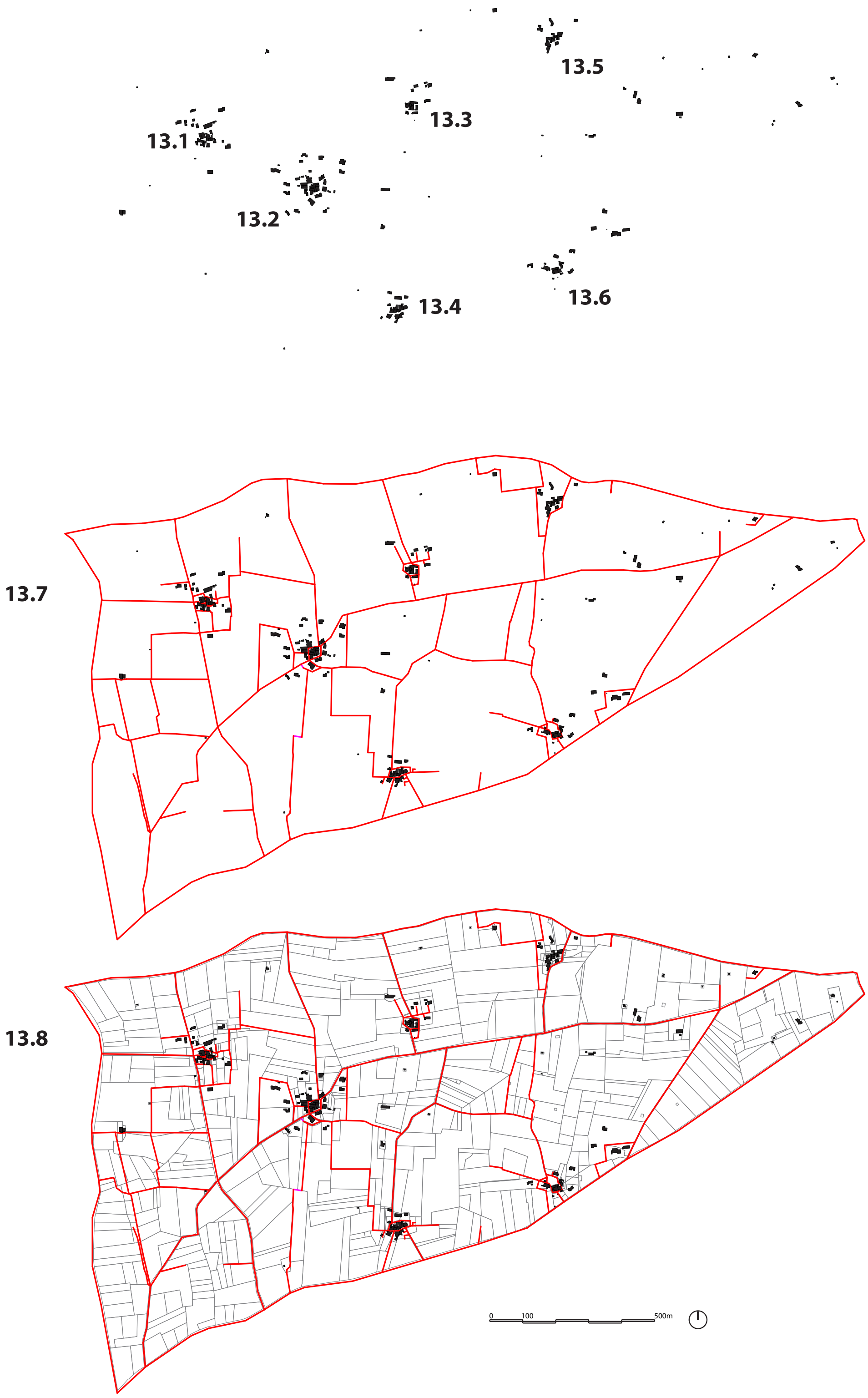


Figure 13:

A cluster of 'beady ring' hamlets.

13.1: Hameau-des-Allemands.

13.2: Hameau-des-Redons.

13.3: Hameau-des-Chaffres.

13.4: Hameau-des-Bruns.

13.5: Hameau-des-Blanchards.

13.6: Hameau-des-Bellots.

13.7: Roads added to the map of the hamlets.

13.8: parcels added to the map of the hamlets, based on the cadastral map.

Figure 14:

14.1: Metric reach, 100 meters network distance radius.

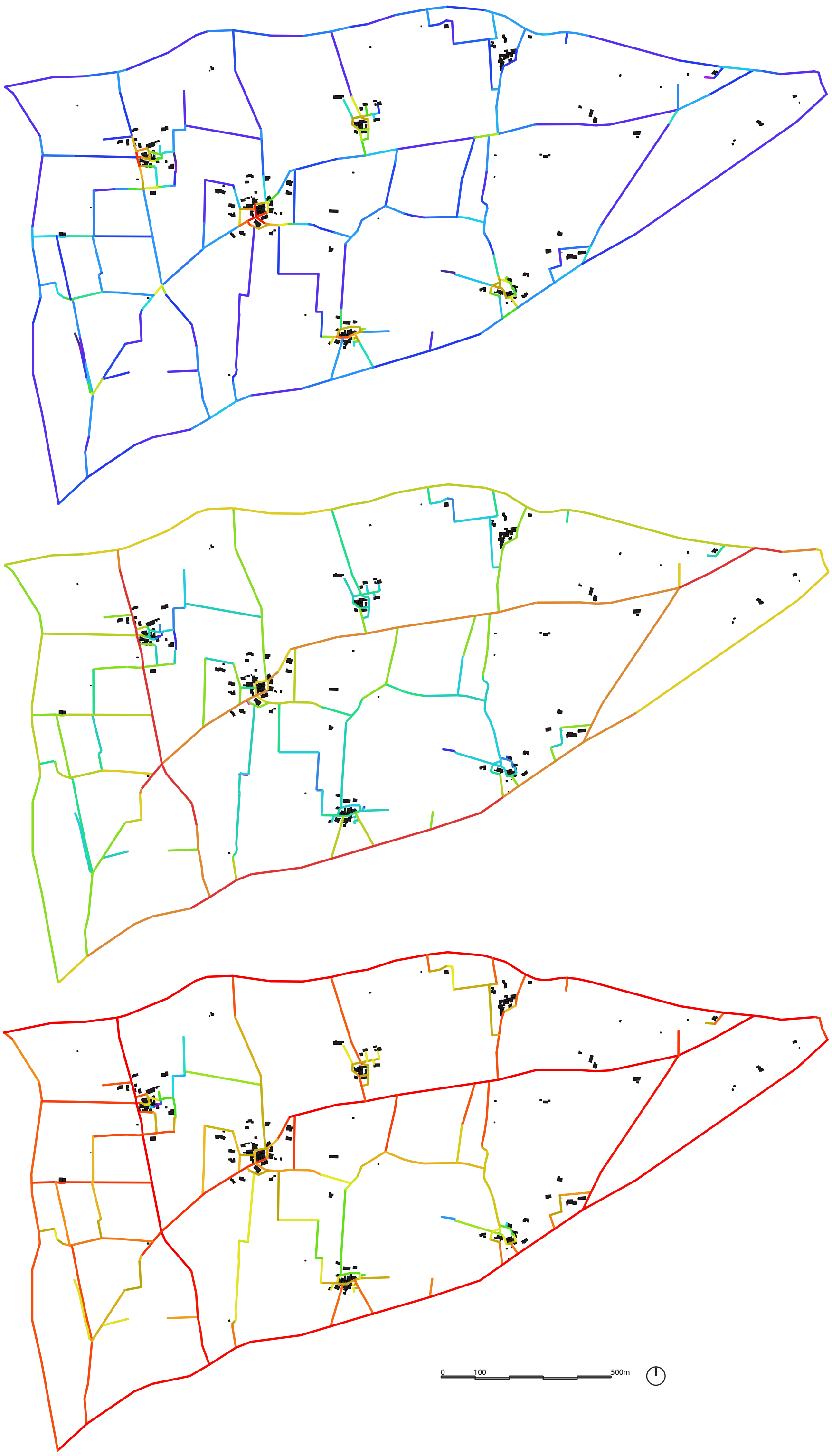
14.2: Angular Integration.

14.3: Directional distance, 20 degrees threshold.

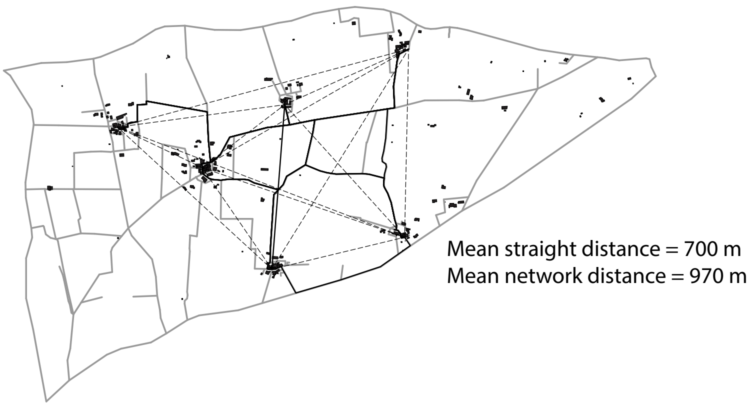
14.1

14.2

14.3



15.1



15.2

15.3

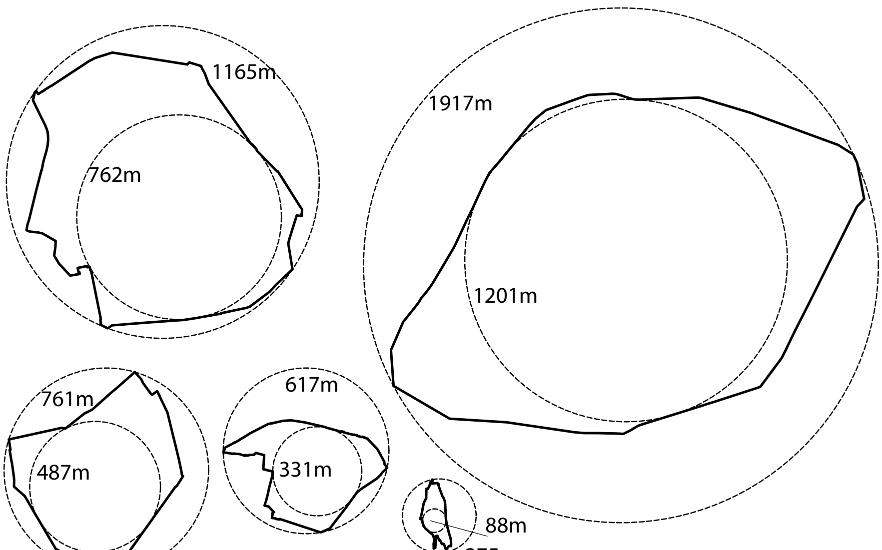


Figure 15:

Key dimensions.

15.1: Shortest distances and network distances between hamlets. Dashed lines represent shortest distances, thicker black lines represent the minimum distance connecting network.

15.2: Outlines of settlements superimposed on the system of hamlets.

15.3: Diameters of inscribed and circumscribed circles for the 5 settlements.

ments, if the geographical distribution of the hamlets is kept intact. Gassin is too small to encompass more than one hamlet. At least two hamlets could fit into Apt or Carpentras, four into Ai-en-Provence and all six into Avignon, as shown in Figure 15.2. More abstractly, the largest circles inscribed into Aix-en-Provence and Avignon have diameters smaller than the mean straight line distance between the hamlets. The same is true of the smallest circles circumscribed around Aix-en-Provence, Avignon, and Carpentras. This is graphically represented in Figure 15.3. In short, the spacing of the hamlets allows us to speculate that several of them could be contained in an area and a shape equivalent to at least the three largest settlements previously analysed.

Supposing then that a third generator process gives rise to multiple settlement nuclei in close proximity, these nuclei would not likely be traversed by straight roads due to the piecemeal logic of aggregation that gives rise to them. Should a larger settlement, first a village, then a town emerge to assimilate such proto-nuclei, the building clumps that are most likely to be aligned to form a main street between them would be those along the sides of pre-existing roads, even as the third generator is still operational. In itself, this would bring about a 'coordination' of new building aggregates, or urban blocks that might evolve along the roads. As the third generator might give way to the seventh, so that the process of growth proceeds by building blocks compactly arranged between radials, so an integration core might form which reaches towards some of the original nuclei but does not traverse them. This hypothetical process would account for the presence of groups of small irregular blocks in different parts of a historically evolved town. No claim is made here that such a hypothetical process underpins the evolution of the particular settlements we studied. The purpose of the argument is to suggest that the distribution of block sizes relative to the distribution of the integration core is not surprising if we were to imagine a process of urban formation which is based on the third and seventh generators.

Concluding comments: Functional and generative explanations of the relation of block size to integration

Design experimentation and empirical evidence suggest that the type of street network integration that has been called a 'deformed wheel' can more easily arise when block sizes and shapes vary. While it is possible to create such a pattern of street network integration under the constraint that block size and shape be constant, the types of design involved could only arise through deliberate and rather contrived effort. Given the apparent congruence between street network integration patterns and block differentiation, the question arises whether smaller block sizes are systematically associated with more integrated streets. In the small sample of towns and settlements of the Provence that we have studied this is not the case at present, nor was it the case at the time of the first Napoleonic cadastral maps available. The evolution of these towns and settlements points to the rationalisation of the deformed wheel pattern of integration through better street alignment, street widening, street extension or new street addition. But it does not point to a systematic association between smaller block sizes and integration, or block size and integration more generally. In the context of plans where blocks are generally small and less than 0.5 hectares, it is possible to interpret this state of affairs from a functional point of view by pointing to opposite pressures. On the one hand, smaller blocks increase street frontage and allow walking distances between any two points to become shorter. This may be conducive to the types of exchange that we may associate with integration: material, informational or social. On the other hand, smaller blocks cannot accommodate all the land uses and building types that may claim a location near the integration core: town halls, churches, and other large buildings will not fit in blocks of very small size. Testing the functional explanation is outside the scope of our paper, but the examination of the maps of the towns and settlements analysed does not lead to its immediate rejection. It rather leads to a sense that it is plausible.

We have pursued a little more intensely a different explanation, one that is based on a hypothesis regarding the generative principles that underpin the patterns under consideration. The starting point is the difference between the third and seventh syntactic generators described in *The Social Logic of Space* (Hillier and Hanson, 1984). While the third generator evokes only the very simple ideas of aggregation and adjacency, the seventh evokes the idea of a coordinated disposition of urban blocks, to form intersecting street rings. Hillier and Hanson associated towns with the seventh generator and small hamlets with the third. We speculated that if villages and towns grew by incorporating multiple small hamlet nuclei, structures of integration would arise whereby small blocks would be distributed in different places, sometimes attached to integrating lines, but without a systematic association between small blocks and integration. We supported this speculation, first by looking at a cluster of hamlets in the Provence, not as separate aggregates, as they are treated in *The Social Logic of Space* (Hillier and Hanson, 1984), but as parts of a system that includes a network of connecting roads. We analysed the system as a whole to reveal a balance between the nodes of aggregation density and the pattern of integration of the connecting roads, which reach but never run through the hamlets. Second, by establishing that clusters of hamlets are characterised by such inter-hamlet distances that two or more hamlets could fit within the area of even the smallest town of our sample – but not of the village of Gassin. In this way, we have suggested that the explanation of the patterns under consideration in terms of function could be complemented by an explanation in terms of generative principles. Thus, we have provided further support to the claim that, in traditional urban forms, the variation of block sizes is an integral part of the space syntax of street networks, not an incidental character of form.

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