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Hippodamus Rides to Radburn: A New Model for the 21st Century

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ABSTRACT *Cities and towns in the Americas and Europe bear the mark of what became known as the innovation of Hippodamus of Miletus. During the 24 centuries since its introduction, founders of new settlements readily applied the Hippodamian grid. However, its enduring prominence declined at the start of the 20th century when alternatives, intended to accommodate the new motor vehicles, were explored. While cities still struggle to absorb the shock of mechanized transportation, the Hippodamian concept is experiencing a renaissance. It gives cities clear structure, comprehensible order, modularity and expandability, among other qualities. Moreover, it is hypothesized that since current mobility devices have all but eclipsed the natural mode of travel—on foot—a return to the grid could reinstate walking as a viable option. It is clearly time for a fundamental re-evaluation of the Hippodamian idea in the context of the dominant automotive mobility and of the quest for walking as an alternative. This paper examines Hippodamus' concept in its historical context and attempts to reformulate it in a contemporary planning framework that encourages walking.*

Introduction

With the invention of wheeled transport, streets were no longer the exclusive, habitual realms of the pedestrian. For the first time street shape, width, intersections, pavement and slope became important for vehicular transportation. The use of new means of locomotion required that streets should be laid out in order to balance the needs of all modes: foot, hoof and wheel.

The recent addition of motor power to wheeled transport brought back the need for balance with renewed urgency. Early in the 20th century planners began to propose abatement as a way to limit the speed and volume of traffic and separation as a way to segregate vehicular and pedestrian movement. Behind these proposals stand the grim statistics of pedestrian and motorist fatalities and injuries and their economic and social costs (Ernst, 2004, p. 11) as well as the attested degradation of the street's social environment in proportion to the traffic volume (Appleyard, 1981). This paper explores the potential for fusing the Hippodamian grid with recent traffic planning schemes to create a model for

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contemporary development that balances the needs of cars and pedestrians, which is a goal universally espoused by planners.

Evidence of the desirability for a safer and more convivial alternative can be found in the most admired and frequented civic spaces in the world: streets and squares that are inaccessible to cars, or districts where traffic is excluded, courts, gallerias, enclosed malls and underground street networks (Rudofsky, 1969). Sponsored car-free days in cities transiently recapture the pleasure of unhampered cycling and walking in the streets.

Several planning schemes that attempt to achieve 'abatement' and 'separation' have been put forward.

R. Unwin proposed a scheme for cul-de-sacs that were connected to a common landscaped spine containing footpaths (Childs, 2004 p. 171). Le Corbusier elevated roads and buildings on pillars to leave the ground unobstructed for pedestrians. C. Stein, following Unwin's lead, separated footpaths entirely from roads. Doxiadis applied Stein's idea on a metropolitan scale (Islamabad) within a 2-kilometre freeway grid. C. Alexander suggested patterns to abate and separate vehicles from pedestrians, and C. Buchanan recommended separation using the plus-15 elevated walkway system.

The Unwin/Stein idea became quasi-institutionalized in the US through Federal Housing Authority guidelines and continues to be applied. Its iconic street type, the cul-de-sac, has been highly praised and heavily criticized.

Some planners currently hypothesize or accept that the Hippodamian grid, or a variation of it, could redress the imbalance between vehicle and pedestrian traffic. This paper suggests that a review of Hippodamus' idea in a historical context, its subsequent applications and transformations as well as its resurgence may point the way toward a constructive metamorphosis that enables and enriches travel on foot without compromising vehicle traffic.

The Search for Balance

Current literature indicates a general agreement that recent planning approaches to laying out road networks in suburban districts generate problems, such as lack of connectivity, disorientation and danger. It is argued that their designs follow mainly traffic engineering norms that focus on vehicle movement and, consequently, overlook pedestrian travel.

From a historical perspective this disregard for the pedestrian may be seen as a transformation in the making. Transformations generally occur when a critical threshold is reached; in this case 'speed'. Horse powered transport tripled the walking speed and brought about new needs for city layouts. Motor power raised travel speed tenfold, a speed largely unused in city travel. Another threshold has also been reached: car ownership has now peaked (at least in the US) to one car per able driver, a condition that puts as many cars on the road as statistically probable. These new thresholds, speed and car ownership saturation, may also demand a new response.

The First Model for Balancing Travel Modes

An explanation of why the grid displaced previous city layouts would require much greater depth in historical analysis than is intended by this paper. However, based on the assumption that transportation means always play a role in the layout of a city plan, (even as a constraint, rather than a guiding principle), this paper ventures into unproven ground with no claim to historical validity. Indirect evidence strongly supports the speculation that the grid, adopted by Hippodamus, was introduced under pressure to accommodate the movement of carts and chariots. This was most probably the case because carts and particularly chariots:

- had been in use for at least a millennium, had high utility value and were symbols of power and wealth;
- moved about three times faster than pedestrians, a speed better served by straight paths;
- could not negotiate turns easily, particularly of acute angles, often found in 'organic', foot-based city plans; and
- had proliferated among the aristocracy and were used for personal travel, sports, civic functions and celebrations as well as recreation (races).

Hippodamus, an eccentric aristocrat and horse owner,[1] had probably experienced in person the mal-adaptation of the 'organic' layout of the needs of chariots. He adopted a street pattern that defied credible criticism, resting on the indisputable grounds of security. Aristotle, writing after Hippodamus' time, believed that, in comparison with the old 'organic' layout, his plans made it easier for invaders to subdue a city (Aristotle, Book 7, 10.4 [1]). Given that the grid was conceived in and for a predominantly pedestrian society, it acknowledged and accommodated travel on foot but, inadvertently, tipped the balance toward the cart and chariot, as he, the alleged Pythagorean disciple, would have known. A radial plan would have been more equitable than the pure orthogonal grid for trips to the centre and across town. Such a plan was later proposed by Vitruvius (50 BC) (Figure 1).

It is plausible that Hippodamus, an architect/planner, social thinker and geometer, attempted to and succeeded in balancing the requirements of the then current modes of travel by adopting the grid. It was a pragmatic solution consistent with the Greeks' approach to city planning (Morris, 1994, p. 54).

A Century of Planning Models: A Brief Review

Antiquity left two clear and easily understood models for street layouts: the Hippodamian grid and the Vitruvian radial plan. Their clarity and, evidently, their functionality, prompted their application in a variety of settings. The grid was

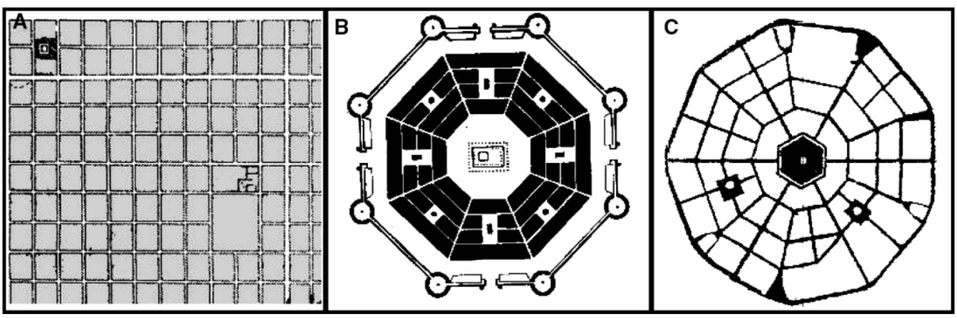

Figure 1. From left to right: (A) a typical Hippodamian grid: 100 city blocks from the Miletus plan; (B) the Vitruvian radial plan; and (C) its application in Palmanova, Italy.

used extensively in the Americas and the radial plan appeared in some of Europe's fortified cities (e.g. Palmanova, Italy; Philippeville, Belgium; Hamina, Finland) and re-emerged sporadically in recent urban and suburban design (e.g. Canberra, Australia; Sun City AZ; Ilioupolis (Athens), Greece).

The 20th century generated many street layout models. In all cases these plans bear evidence of concern for the pedestrian and, in most, of an attempt to resolve conflicts between foot and motorized travel. This concern found expression in models that were implemented mostly at the urban fringe and in many cases only partially, because few opportunities were available to build new cities and test whole city models. All models attempt to resolve the conflicts that have resulted from increased traffic volumes: wheeled traffic is 'abated' to facilitate foot traffic; wheeled traffic is 'separated' from foot traffic; and traffic is encouraged to move along a 'hierarchy' of streets where pavement width and distance between intersections are scaled to motor speed and volume.

'Abatement' is achieved by the use of cul-de-sacs and T-junctions that arrest or complicate a motorist's movement. T-junctions were recommended in the 1890s, before the motorcar emerged, for better traffic flow and for visual effect (C. Sitte, 1889). Similarly, in the 1880s, Eugène Hénard effectively turned cross-intersections into T-junctions by introducing roundabouts (Wolf, 1969). 'Separation' of paths, only necessary when many travel means coexist, lets both pedestrian and motorist move unimpeded. A 'hierarchy' of streets required for motorized transportation accommodates higher flows as destinations become more distant and more motorists take these, normally fewer, longer-distance connectors (Salingaros, 2003, p. 16).

Table 1 illustrates how each of eight 20th century street layout models addresses the issues of abatement, separation and hierarchy.

The following briefly explores these models and concentrates on the methods used to resolve the conflict between foot and motorized mobility. This review rests heavily on secondary sources and aims to create a canvas of solutions, which can be abstracted and metamorphosed in search for a workable composite.

Table 1. Elements in dealing with the pedestrian/vehicular conflict that are included in 20th century planning models

	Abatement		Separation		Hierarchy
Models	Dead-ends and loops	T-Junctions	Distinct footpaths	Over/Under passes	Local, collector, arterial streets
E. Howard	No	Some	Pre-motor	Pre-motor	Pre-motor
Unwin/Stein	Yes	Yes	Yes	Yes	Yes
C. Perry	No	Yes	No	No	Yes
Le Corbusier	Yes	Yes	Yes	Yes	Yes
Doxiadis	Yes	Yes	Yes	Yes	Yes
Milton Keynes	Yes	Yes	Yes	Yes	Yes
Alexander	Yes	Yes	Yes	N/A	Yes
Tradit. N.D.	No (some)	Yes	No	N/A	Ambivalent

Notes: ITE's *Traditional Neighbourhood Development Street Design Guidelines* (1999) states that "While TND street networks do not follow the same rigid classification of conventional neighbourhoods with local, collector, arterial and other streets, TND streets are hierarchical to facilitate necessary movements" (p. 21).

In roughly chronological order, the review follows the trajectory from pre-motorcar planning ideas to concepts that accommodate the car fully. While these ideas were being implemented in greenfields, existing neighbourhoods were also feeling the negative effect of increasing traffic and began to voice the desire for change. By the third quarter of the 20th century, some neighbourhoods revolted and forced street closures (Berkeley, CA 1975 and Seattle WA, 1973) in what was to become a new branch of traffic engineering—'traffic calming' (Ewing, 1999). Traffic calming advocates 'abatement' by closures, diversion, one-way streets and other measures. This implicitly creates a 'hierarchy' as some streets inevitably mutate to collectors and arterials. Apart from the change in level between sidewalks and driving surfaces, 'separation' is impractical at grade (given the invested real estate capital) and occurs in above- or below-grade paths in dense central districts. The Dutch planner Nick de Boer introduced the Woonerf concept (1969) as a retrofit to existing streets. An early attempt to reconcile the needs of motorists and pedestrians in residential neighbourhoods, it uses a street shared by cars and pedestrians, who are given priority.

These retroactive measures brought into sharp focus the urgency of proactive design that would preempt the need for such measures in the future. The search for a complete solution that began with E. Howard continues to this day. His Garden City (1902) diagram articulates a regional model of city growth. Based on the then current combination of rail and foot modes of travel, his model does not deal with the potential conflict between motorcars, which had only begun to emerge, and pedestrians. The road pattern diagram, drawn as a guide only, imitates the Vitruvian radial plan and clearly favours foot travel (Figure 2, left). However, at three times the radius (0.75 miles) and about six times the area of the original, it would limit what a person is capable of reaching on foot (website by John W. Reps, Cornell University).

The subsequent elaboration of the Garden City idea by Unwin and Stein resolves the conflict between pedestrians and motorists with a full separation of pedestrian from vehicular traffic by means of cul-de-sacs and footpaths. However, the diagrams and built examples, such as Radburn (1928), that incorporate these refinements are limited to the scale of a single neighbourhood (Figure 2, no. 2). In these cases the garden city idea of 30 000 people is scaled down to the garden suburb and, in some projects, to simply a garden neighbourhood of a metropolitan city. Multiple, contiguous 'Radburn' neighbourhoods would require another layer of road structure before they could be viable models for city-scale planning. This layer of structure was provided later by Le Corbusier, Doxiadis and the designers of Milton Keynes. Stein's composite block or 'superblock' codified the idea of road hierarchy that was implied by Perry's Neighbourhood Unit. Road hierarchy became a key element of all subsequent models and standard traffic engineering practice.

Clarence Perry's Neighbourhood Unit model (1929) also concentrates on the neighbourhood, which he defines in social and in planning terms. The plan of the unit, as exemplified in a sample layout, (Figure 2, no. 3) resolves the conflict by limiting through traffic. It assigns district traffic to the periphery. Through traffic is reduced by replicating the irregular geometry of 'organic' cities and by introducing a large proportion of T-intersections. The plan also uses the Vitruvian idea of radial streets. While its programmatic expression is clear, its layout remains idiosyncratic and difficult to codify and may be impractical. For example,

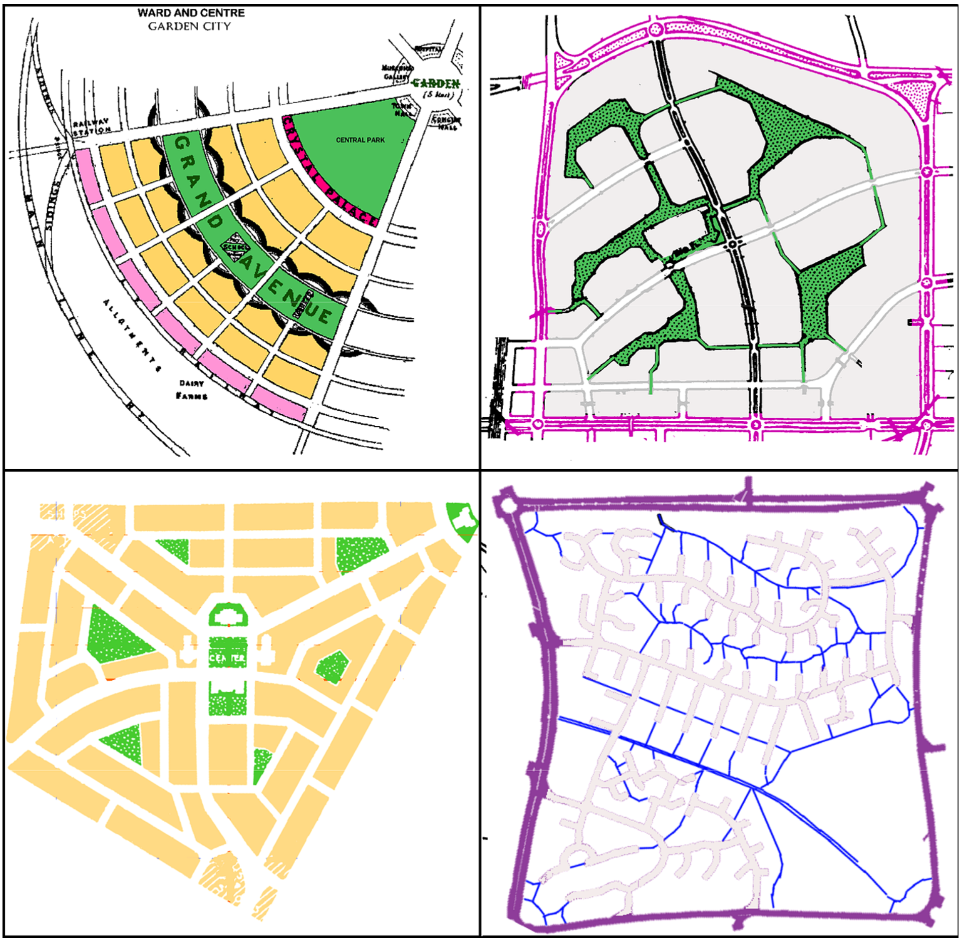

Figure 2. Four 20th century concepts for dealing with pedestrian and vehicular movement in cities. *Notes:* 1. Howard's *Garden City* eases foot travel. 2. Stein's garden district separates pedestrian paths. 3. Perry's neighbourhood unit inhibits through traffic. 4. A 'sector' in the town of Milton Keynes provides separate pedestrian and vehicular paths.

directing traffic to the corners of the unit may be problematic for traffic flow and safety.

Le Corbusier's Ville Radieuse (1935) is a clear, comprehensible model for a whole-city road network that extends the efforts of Stein and Perry beyond the scale of the neighbourhood. In theory, it resolves the conflict between cars and pedestrians with a radical, unconventional solution: grids of motorways and large buildings are raised above ground to give pedestrians full, unobstructed use of the land. Its orthogonal grid, following its Hipodamian predecessor, generates blocks or 'sectors' that are primarily pedestrian precincts by discouraging through traffic. In its practical application to a full city, Chandigarh (1950), it solves the conflict by applying a Radburn-like pattern of green spines and footpaths at the neighbourhood scale (Figure 8, no. 2). Most roads meet at T-intersections. Pedestrian connections between the 800 × 1200 metre sectors, each containing one or more neighbourhoods, use under- or over-passes to complete the foot-based network.

In his Ekistics studies and projects, Doxiadis, elevates the Radburn pattern of building neighbourhoods into a basic component for building cities (Islamabad, 1960) arguing the need for separating the 'human scale' from the mechanical one (Figure 3, left). Dead-end roads become the dominant street type and T-intersections the most frequent at the neighbourhood scale. As in the original, the cul-de-sacs are connected to paths within a green spine. Four such neighbourhoods, arranged roughly in a pinwheel, create a 2 × 2 kilometre 'sector' that is framed by freeways and wide green zones (Figure 8, no. 1). The sector is meant to be self-sufficient for the daily cycle of activities that can be fulfilled on foot. The Hippodamian grid returns at the automobile scale to provide a clear regional structure and its orthogonal geometry permeates the sector plan.

The English town of Milton Keynes (1967–80) is also notable for its introduction of a regional structure that includes the city-scale transportation network missing in Radburn and the Neighbourhood Unit. A 1-kilometer grid of arterials, that is adapted to the topography, forms the transportation skeleton of the town (Figure 3, right). A distinct, separated pedestrian pathway system weaves through green spines behind the building blocks (Figure 2, no. 4). Vehicular streets within each grid frame intersect only in T-junctions, as do most collectors where they meet the peripheral arterials. Thus this model, as the previous, offers both abatement and separation of traffic (MK Development Corporation, 1970 and D. Walker, 1982–45). However, neighbourhood street layouts follow an informal, meandering pattern with no apparent rule. In contrast, the layout for the city's centre, where most of the traffic would gravitate, is a strict orthogonal grid. This proximate juxtaposition of orthogonal and meandering layouts poses the question of which pattern would offer city centres the same level of abatement and separation that is afforded its neighbourhoods.

Alexander developed a series of Patterns to deal with the conflict between car and pedestrian movement (Alexander *et al.*, 1977). Patterns 49, 50, 51 and 52 proclaim looped roads as the most suitable type at the neighbourhood scale followed by connected cu-de-sacs; assert T-junctions to be the safest type for use

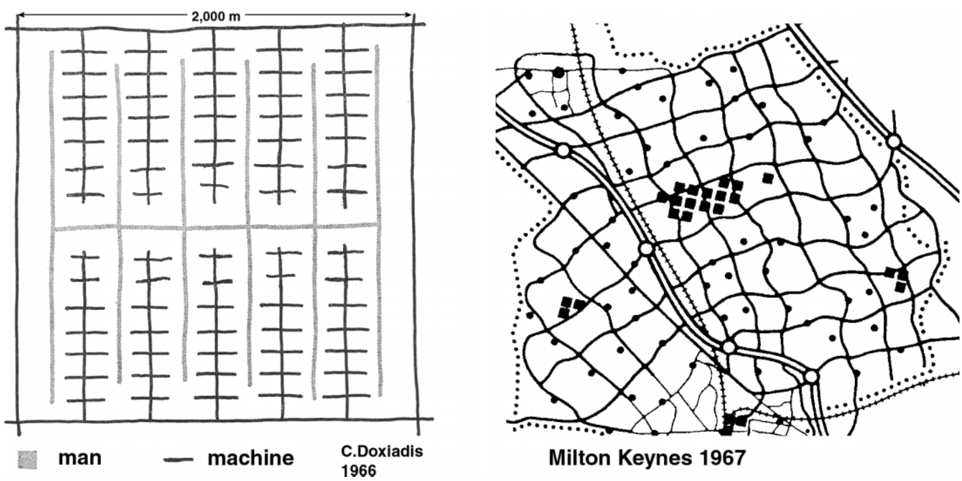

Figure 3. Doxiadis's sketch for a 'man-machine' separation within a 2 km square area framed by motorways (left) and the Milton Keynes 1 km square grid (right). *Source:* Sketch adopted from Doxiadis, *Anthropopolis* (1975).

within neighbourhoods; propose a separation of pedestrian paths from roads; and suggest that some streets with houses on them may be made inaccessible to cars. While these four patterns form a complete set in redressing the imbalance between pedestrians and motorized traffic, their combination into a structured neighbourhood and district model remains an incomplete task in theory and in application. However, they have been applied individually, partly because they have been already in the planning vocabulary for over 50 years.

Traditional Neighbourhood Design (TND) advocates a return to a modified Hippodamian grid. The specified modifications are meant to enhance the visual attractiveness of the street by avoiding long straight vistas, and to emphasize public buildings by terminating streets in front of them. Streets are seen as the only and sufficient carriers of vehicular *and* pedestrian movement. TND principles emphasize connectivity for all modes and the diffusion of vehicular traffic throughout the street network. However, TND does espouse traffic abatement within neighbourhoods and discourages through traffic in them by the use of T-junctions and narrow or one-way streets in specific instances (ITE, 1999, p. 7). It recognizes the need for regional high volume thoroughfares and places them at the periphery of a roughly 64 hectares (140 ac) neighbourhood (ITE, 1999, p. 7). As a model, it focuses on the neighbourhood for which it offers a set of layout instructions, street sections and images but no functional diagram.

A Proposal for a Renewed Balance: The Fused Grid

It can be safely assumed that motorized transport will continue to move people and goods in the foreseeable future as carts and chariots did for over 30 centuries. Street patterns endure for centuries, which poses a serious design challenge: to devise a road network layout that will remain fixed yet be flexible enough to accommodate unpredictable change and work well for all modes of transport.

It is worth noting at his point, that none of the inherited or proposed models has been tested for functionality, robustness or flexibility. Vernacular experience and ‘common sense’ drove their birth and application. Gradual adaptations that solved dysfunctional aspects of inherited patterns, now taken for granted, are the only ‘proof’ of a malfunctioning model. In this vein of retroactive empirical proof, studies on the correlations between network patterns or the effects of traffic calming measures on the number of accidents show conclusively the potential for improvement and, hence, the inadequacies of the original plans (Lovegrove & Sayed, 2006; also Elvik, 2001).

The above review of conceptual models for neighbourhood, district and city layouts reveals the commonalities and differences in street patterns that seek a balance between wheeled and pedestrian movement. One element on which there is general agreement (at least at the level of professional guidance and practice) is the use of T-junctions for traffic abatement. Another is the use of a hierarchy of streets, beginning with heavily-used inter-city highways, and permitting less traffic on progressively lower level streets. A third element that most models include is partial or complete separation of footpaths from vehicle routes. These paths are generally set in a common green space.

To systematically re-combine these three elements in the layout of a neighbourhood, once again there is a turn to geometry. It has been shown that a hierarchical pattern can be created that is based entirely on the principle of T-intersections (Batty & Longley, 1994, Figures 2–13) using fractal progressions.

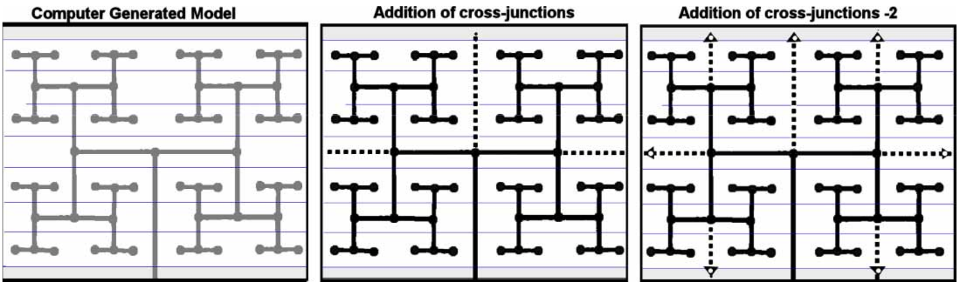

Figure 4. A theoretical pattern of streets generated by using the principle of T-junctions as the primary condition. A normal and gradually denser grid is created by extending specific stems. *Source:* Adopted from Batty (1994).

A clear structure is shaped by a virtual grid. This abstract design can be a starting point for a neighbourhood street pattern. However, while it offers absolute control of traffic volume (abatement), its strict dendrite structure would favour neither pedestrians nor drivers. To rectify this flaw, through streets would have to be created to ease motor traffic flow and, similarly, special paths for pedestrians would be needed (Figure 4, nos. 2, 3).

A second approach to achieve abatement, separation and hierarchy involves returning to the most basic Hippodamian grid geometry and systematically replacing cross intersections with T-junctions and, where possible, vehicle streets with pedestrian paths or bivalent (Woonerf-type) streets. This transformation can be done at the same level of abstraction as above, using the nodes and links vocabulary of codifying a street pattern (Figures 5 and 6).

In making these transformations additional design intentions common to most reviewed models should be kept in mind. These intentions represent the "…dilemma for the designer committed to a more structured design" like the geometric grid (Southworth & Ben-Joseph, 2003, p. 133). Attributes considered desirable for urban structure are: clear, coherent, legible, memorable, recognizable, regular, robust, well connected, hierarchical and interconnected (Marshall, 2005, appendix 2).

Maintaining the orthogonal geometry of the Hippodamian grid ensures clarity and legibility, which are common objectives of all models. Figures 5 and 6 show the gradual transformation of the Hippodamian grid (e.g. as found in Portland, OR). The sequential, selective replacement of cross junctions with T-junctions first leads to eight looped roads within a 'neighbourhood' unit (step 3) and finally to eight cul-de-sacs that are connected with footpaths (step 4). Thus abatement is achieved by limiting traffic to local only. Separation is achieved

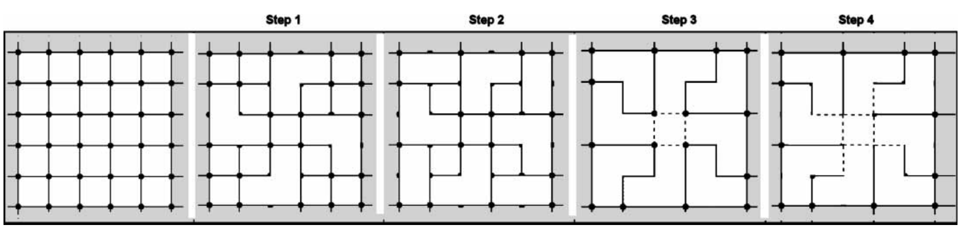

Figure 5. Transformation of the Hippodamian grid: cross intersections are replaced with T-intersections and some street segments with pedestrian paths within a 400 m square area.

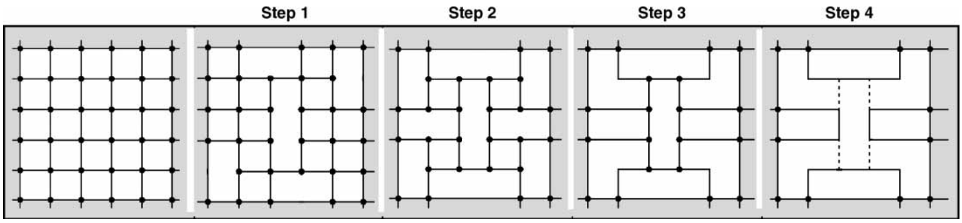

Figure 6. Transformation of the Hippodamian grid: cross intersections are replaced with T-intersections and some street segments with pedestrian paths within a 400 m square area.

by providing paths, which are extensions of the streets that could be partially or exclusively pedestrian.

Figure 6 shows a transformation that results in an alternative final street configuration of four loops connected by pedestrian paths. These two schemes show the potential of using the same base and technique to arrive at many neighbourhood unit configurations. The expected outcome is a repeatable composite block that excludes vehicular traffic and establishes a pedestrian realm.

Figure 7 shows four layouts, some of which combine elements of both previous transformations. Variations on these configurations are possible and all provide for abatement and separation, the latter to varied degrees. All prevent through traffic while creating safe uninterrupted pedestrian paths to the perimeter. They also reintroduce the idea of the Vitruvian diagonal movement for pedestrians, though less directly than in a radial plan.

Consistent with contemporary planning and engineering guidance, these local streets would be narrow, and wider district connectors would be located at the periphery. Where unnecessary turns and dead ends were abolished in Hippodamus' scheme to facilitate wheeled traffic, they are reintroduced in a Fused Grid neighbourhood for the purpose of calming down traffic. The periphery of the composite block, where amenities would probably be situated, can be reached on foot, in some cases without crossing a single street. The Fused Grid adapts a 'good' nested hierarchy of roads that are interconnected rather than dendrite (Marshall, 2005, pp. 35, 36).

The Fused Grid structure is based on a cellular construction (Batty & Longley, 1994, pp. 25, 44). It uses a module 400-metre square, which represents the limit to foot travel and which creates a practical intersection frequency for cars. It is primarily a network diagram that deals with the pedestrian/car conflict. It does not prescribe, but anticipates, an overlay of street sections and their features as well as buildings and land uses that would evolve out of context-specific requirements. Two aspects of the Fused Grid as a transportation model were analyzed, its traffic performance and its potential to encourage travel on foot, and

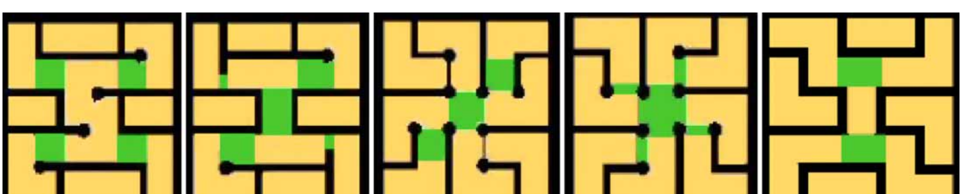

Figure 7. Five typical neighbourhood quadrants (400 m each side) based on transformations in Figures 5 and 6.

the results show a significantly better performance than current alternatives (IBI Group, 2008; Frank & Hawkins, 2008).

The neighbourhood street layouts respond to the objectives of each of the 20th century models that were reviewed and may resolve some of the weaknesses that emerged in their applications:

- Stein's *composite block*, which is essentially a pedestrian precinct free from through traffic, is evident in these layouts as is the presence of a green spine (or structure) through which residents may travel on foot to their daily destinations. The new layout (a) resolves the ambivalence of house front and back in Radburn by having local streets function as main access routes; (b) regularizes and repeats blocks; and (c) turns open spaces into focal points having the familiar character of a village square, to which streets converge or from which they emanate. The infrastructure economies in Radburn are maintained by this plan.
- Perry's Neighbourhood Unit would be replicated by combining four Fused Grid blocks that yield his recommended 160-acre size. As in his plan, open spaces are dispersed, treated as urban blocks and use 10% of the area. His intent to limit through traffic is realized with regular repeatable patterns rather than contrived 'organic' geometry. The possibility of placing denser housing, institutions and commercial at the periphery is also consistent with his plan (Figure 10).
- Le Corbusier's rational transportation grid is found here at a graduated scale of traffic volume and always *within* a contiguous urban fabric. All roads would join rather than separate neighbourhoods, except for freeways. The self-sufficient district or 'sector' with its own 'centre', whose success has been debatable at best, becomes a network of 'zones' at the periphery of neighbourhoods along the major routes, where traffic supplies the users that the amenities within them need to stay viable, in the way that Perry had envisioned (Figure 8).
- Milton Keynes' 1-kilometre transportation grid is found in the Fused Grid 4-quadrant module (Figure 9). The Fused Grid layout respects the intentions of the original but becomes more regular and repeatable, rather than 'unique'. Perimeter roads change from barriers to connectors and adjacent land from green buffers to activity zones. Crossings occur at grade rather than over or under. Grade-separated crossings would be welcome to pedestrians when associated with intense development. A 'centre' district would be laid out as a Fused Grid quadrant creating a fully pedestrian precinct, as in the transformed centres of old cities (Figure 10, right).

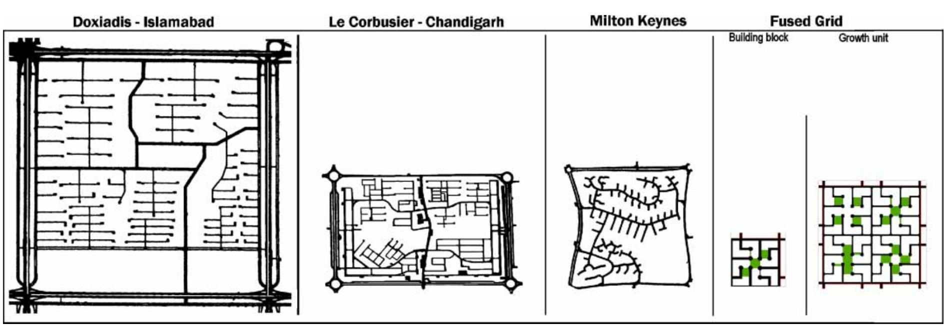

Figure 8. Growth Unit Size varies considerably among 20th century models (all drawings to approximately the same scale).

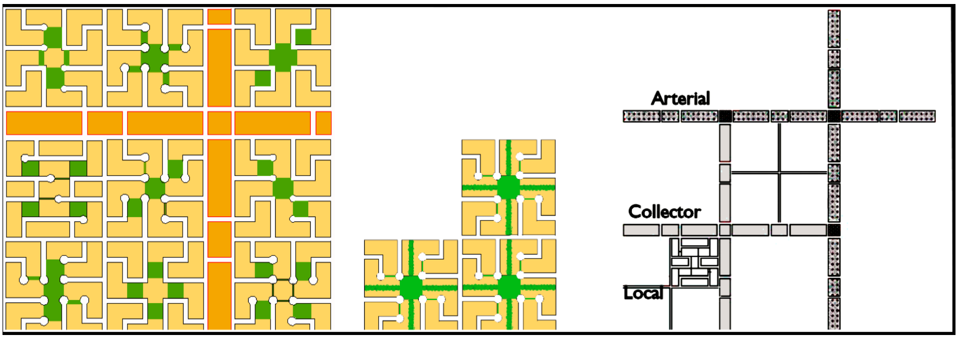

Figure 9. The structure of the Fused Grid. Four neighbourhoods (16 ha. each) form a composite Neighbourhood Unit (64 ha). It is bounded by parallel roads that frame common uses. The transportation network structure continues to the next level of hierarchy (right). All urban space is contiguous unless interrupted by highways or parkways.

- Doxiadis' principles are found in the proposed layout but at a much smaller scale. A Fused Grid district covers a quarter of Doxiadis' 'sector' (Figure 8). The hierarchy of roads is maintained, but collectors and minor arterials include fronting properties and function as urban activity zones, as opposed to pure traffic conveyors. The neighbourhood enclaves are protected from through traffic and access to daily destinations can be on foot. The maximum distance to any place in the district is reduced from 1 kilometre in the Doxiadis plan to 400 metres.
- Alexander's elementary neighbourhood unit is also present, but slightly larger (400 yards across instead of 300 yards in his proposal.) His goal to completely separate pedestrian and vehicular paths can be realized with a modified Fused Grid unit (Figure 9, middle). Accessible squares and green streets (patterns 60, 61, 51) are present throughout the neighbourhood. Similarly, *market streets* (pattern 32) could be created at the periphery of four combined units and the diversity of shops would be proportional to the traffic volume that these larger streets carry.
- TND's intention to place high-volume roads at the neighbourhood perimeter is applied systematically in the Fused Grid (Institute of Transportation Engineers, 1999, p. 7). A pedestrian scale for these streets is maintained by providing a fractal hierarchical structure of district roads in pairs (Figure 9). These pairs provide the needed traffic capacity while retaining normal street dimensions. Complete pedestrian connectivity at the neighbourhood scale is provided by traditional devices such as streets, paths, green lanes, courts and open spaces (Duany *et al*., 2006, p. 8). By methodically excluding through traffic, as TND's encourage, local streets assume a pedestrian character by being narrower and quieter. Interconnected car routes occur at 400 metre and 800 metre intervals, which is a good scale for motorized traffic. Rear lanes could be included where justified on economic, environmental and functional grounds.

The brief summary above explains how the Fused Grid encompasses positive elements of previous models while removing some of their shortcomings and shows how walking can be made safer and more enjoyable. However, meaningful walking happens when desirable destinations are within reach. This was the case in Hippodamus' time and during the subsequent history of walk-based cities;

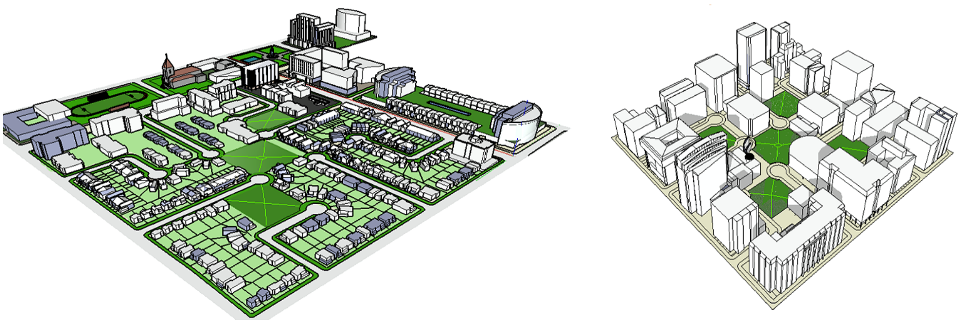

Figure 10. Left: a 16 ha residential district framed by a zone of diverse common uses; right: model of a neighbourhood near a city core developed at higher intensity.

most cities did not extend beyond walking distance and their public spaces and buildings were generally placed at the centre of the district.

The 20th century models recognize the reality of motorized transport, such as tram, bus and car, and aspire to create activity centres within walking distance. The nature and placement of these 'centres' as well as their fate has been widely debated in literature. In contrast to these aspirations, land-use maps of contemporary cities show a clear affinity between transportation and the location of facilities and amenities, which are often dispersed along main arteries as 'High street frontage' or strip malls (Calthorpe, 2002). The tradition of concentrating commercial activity at crossroads has persisted in all modern cities.

The Fused Grid embodies this tradition by assigning areas along main routes about 1 kilometre apart, separate from the housing blocks and capable of becoming pedestrian precincts of their own (Figure 10). This scheme adapts Kevin Lynch's concept for improving the arterial strip (Banerjee & Southworth, 1990, p. 609, Figure 13) and turns it into a structural principle. The density and variety of activities in these zones will follow their own synergies but, whatever their nature, they will always be at a walkable distance from surrounding neighbourhoods. When combined with workplaces, the intensity of activity will increase as will the likelihood that people will walk to and from these zones.

When these common activity areas are fully pedestrian and separated from traffic, as in contemporary car-free districts or malls, the balance between vehicle and foot travel will be fully accomplished; both residential and common areas will acquire the same intense pedestrian character that could be found in pre-automobile cities.

Summary

From this brief review of street network models it may be concluded that, strictly from the pedestrian point of view, two major changes have occurred in their evolution: first, when the Hippodamian grid opened the network fully to wheeled traffic (5th century BC) and second, when Unwin, Stein, Doxiadis and their followers closed portions of the network to motorized traffic (20th century AD). All other network types appear to be variations of these two. The first change usurped the street space, confined pedestrians to its edges and made walking progressively more unpleasant. The second granted pedestrians partial independence and added delight to walking.

The proposed Fused Grid model is an alternative which combines these two principal models: it overlays the geometric Hippodamian structure of the open grid network on the idiosyncratic, picturesque layout of the partially closed network of earlier 20th century plans. It thus creates repeatable units of growth, analogous to the Hippodamian blocks that allow pedestrians and motorists to reach their destinations with relative ease. It maintains full pedestrian connectivity at the neighbourhood unit scale and uninterrupted traffic flow at the district and regional scale. Thus a balance is achieved by making walking easy and pleasant and driving expedient for longer destinations.

Note

1. Hippo, an ancient Greek name prefix, implies horse ownership and, consequently, class distinction (Th. Fotiou, Professor, Classics Department, Carleton University, personal communication).

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