TOWARDS A FUNCTIONAL CLASSIFICATION REPLACEMENT

Laurence Aurbach
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ABSTRACT

Functional classification is the central, guiding idea underlying the roadway system in the U.S., yet it has numerous flaws and negative impacts. A replacement is proposed that is more efficient, safer, less polluting, and supportive of a better-quality built environment: a sustainable network classification. The historical background and main characteristics of functional classification are reviewed. Several of the leading alternative roadway classification systems are evaluated in terms of their scope and focus. The sustainable network classification is introduced, its key tenets organized by block scale, neighborhood scale and city scale. The block scale relationship relates person-capacity to place context. The neighborhood scale relationship relates network accessibility to land use movement sensitivity. The city scale concept organizes inter-network and inter-scale relationships by settlement scale. Additionally, the congestion-related impacts of a sustainable network are discussed.

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INTRODUCTION

Every field has its foundational working concepts and the field of traffic engineering is no exception. It has a concept called *functional classification*, which is the core, guiding idea underlying the roadway system of the United States and many other nations. Functional classification is the conceptual foundation of the auto-dependent built environments where most Americans live.

The primary vision of functional classification is moving more and more cars at faster and faster speeds. This has certain benefits, but also a wide range of disastrous consequences for the built environment and the people who live in it. Hundreds, possibly thousands of reform-minded transportation planners and engineers have determined that the roadway functional classification system should be replaced.

It should be replaced by guiding concepts that support a more efficient, safer, less-polluting transportation system – concepts that support a wider range of choices for neighborhood living and daily travel. What factors should be considered when formulating a sustainable transportation system? What proposals have already been made? This essay explores those questions and proposes a replacement: a sustainable transportation network classification.

THE FUNCTIONAL CLASSIFICATION SYSTEM

Functional classification came into practice in the 1920s and 30s, and it was codified into official recommendations in the 1960s and 70s. It is the core concept that informs traffic engineers and planners what types of roads to build and how they ought to connect (Figure 1).

"Mobility" generally means travel speed. "Land access" means the frequency of intersections and driveways on a stretch of thoroughfare. The relationship shown by the diagram is: As mobility increases, land access decreases.

In practice, functional classification results in three rigid postulates:

- The longer the trip, the bigger the roadway

- The bigger the roadway, the faster its traffic should travel

- The faster the traffic on the roadway, the more isolated the roadway must be from its surroundings

Relationship of Functionally Classified Systems in Serving Traffic Mobility and Land Access
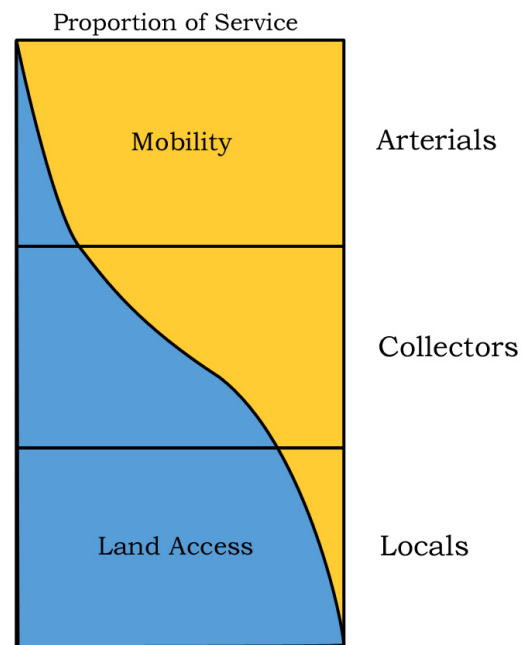
Figure 1: Functional classification

The effect on transportation in America is obvious and immense: The large majority of traffic in urban areas is channeled into freeways and arterials.

Functional Classification: VMT and Roadway Miles
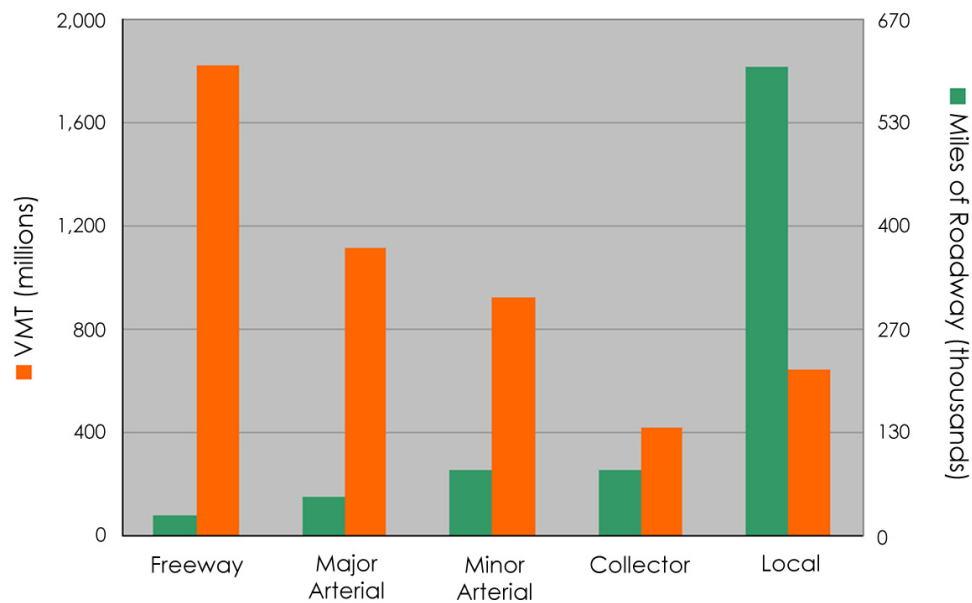### U.S. Urbanized Areas 2006

Figure 2: Vehicle miles traveled compared to miles of roadway. Most vehicle travel is channeled on to a relatively small number of highways and arterials. Credit: Laurence Aurbach, based on *2006 FHWA Highway Statistics*.

Instead of protecting people from high-volume, high-speed roads, functional classification channels traffic into those roads. They run everywhere, especially the places where most Americans live, work and play. Functional classification creates disconnected, dendritic (branching tree-like) thoroughfare patterns. It is the underlying foundation of anti-urban, car-dependent landscapes that are so familiar in the suburbs and exurbs of U.S. metropolitan areas.
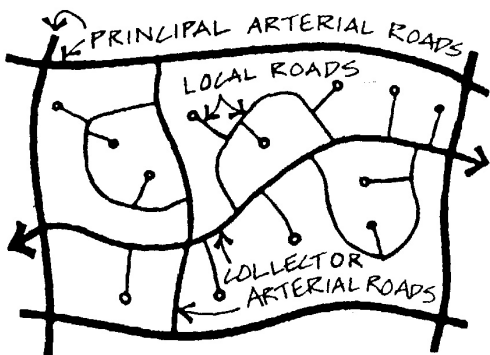

Figure 3: Schematic of functional classification and neighborhood layout. Image credit: Snohomish County Transportation Authority

Figure 4: Functional classification realized on the land in Chantilly, Virginia. Photo credit: USGS

Functional classification has been criticized by numerous commentators (Greenberg and Dock, 2003). Among the criticisms: There is no recognition that thoroughfares have a transportation function **and** a place function; a severely reduced and oversimplified choice of thoroughfare types; no concern for pedestrians; and no concern for the environmental quality of streets and their contexts. Roadway design is determined by demand/capacity formulas, which dictate that roadways become endlessly wider as population increases. The negative economic, social and environmental consequences include more miles driven

Note: For the purposes of this essay, a thoroughfare is defined as any transportation facility that carries motor vehicle traffic from place to place. It includes all sizes of facilities, from lanes and alleys to streets, avenues and boulevards.

*Note (for traffic planners): Limits on driveways and curb cuts on busy streets are a very effective and important part of safe street design. This essay's criticisms of the land access aspect of functional classification are **only** directed at intersection spacing standards. Other techniques of access management that can maintain a high level of connectivity and small, walkable blocks are recommended. See* Connectivity Part 7: Crash Safety.

every day in cars, more congestion, more crashes, more pollution, more suburban sprawl and less walking (Aurbach 2006, 2007; Hall 2003; Jabobs 2003; Kulash 1996; LaPlante 2007; Scheer 2005).

SEEMED LIKE A GOOD IDEA AT THE TIME

For all its limitations, negative impacts and ill-considered consequences, functional classification is based on a logical, sensible idea. It is a rule of thumb that originated during the 1920s and 30s, a time when rail was the primary means of inter-neighborhood and citywide transportation in the U.S. It is derived from the arrangement and operation of urban rail transit:

Update (added 06 November 2014): Functional classification was not conceived as a reflection of rail operations. It developed piecemeal over a period of decades with little or no reference to the rail precedent. The similarity to rail operations is merely an illustrative analogy.

- Local service by trolley was slow (barely more than bicycling speed). Stops were frequent (a stop every block or two). Trains were small (one car).

- Intermediate-scale commuter rail was faster. It covered longer distances between stops (one stop per neighborhood). Larger trainsets were more common (several cars).

- Regional scale travel had the fastest sustained speeds and the longest distances between stops (one stop per town or village). At first it was served by heavy trains (largest trainsets, multiple cars), later filling in with interurban streetcar service (one or two cars).

In summary: The farther the service, the faster the operating speed and the less frequent the stops.

All of these rail networks operated in walkable places. Whatever the characteristics of urban rail trips – no matter whether they were long or short, fast or slow – they always served pedestrians. Pedestrians boarded from walkable places at trip origins and pedestrians disembarked to walkable places at trip destinations. Urban trains operated in the context of small blocks, well-connected street networks, and mixed land uses in close walking proximity. Walking took place in streets, i.e., travel ways lined with buildings that spatially defined a continuous, linear civic realm.

World War I devastation and the mass production of automobiles started to change all of that. In 1920s Europe, anti-urbanist designers proposed an idea of astonishing hubris: to turn the urban transportation relationship inside out. The trip distance/speed/stop frequency relationship would be applied

to car traffic, but with a critical difference. No longer would transportation operate in the context of the walkable city. Instead, the city would be remade to serve the transportation mode. The concept of the street as it had been known for millennia was exploded and discarded; walking would no longer serve as a utilitarian travel mode.

> The present idea of the street must be abolished: DEATH OF THE STREET! DEATH OF THE STREET!
> – *Le Corbusier,* The Radiant City *(1933), p. 124*

Meanwhile in the U.S. a pitched battle for control of urban streets was underway. Today we assume that automobile domination was the uncontroversial result of mass auto ownership. But until the 1920s, every street in America was a "shared space" street, where all pedestrians had the right to use the roadway at any time or at any place they desired. Many, including police, safety officers and traffic engineers, fought to keep it that way by strictly limiting autos to nonlethal speeds. The opposition – auto, oil and road-building industries – spearheaded a movement to ban pedestrians and dedicate streets to ever-faster motor vehicle traffic. Norton (2008) recounts this forgotten history:

> Today we tend to regard streets as motor thoroughfares, and we tend to project this construction back to pre-automotive streets. In retrospect, therefore, the use of streets for children's play (for example) can seem obviously wrong, and thus the departure of children from streets with the arrival of automobiles can seem an obvious and simple necessity. Only when we can see the prevailing social construction of the street from the perspective of its own time can we also see the car as the intruder. Until we do, not only will we fail to understand the violent revolution in street use circa 1915-1930, we will not even see it. This is why the full scale of the wave of blood, grief, and anger in American city streets in the 1920s has eluded notice.
> - *Peter D. Norton,* Fighting Traffic, *p. 2*

Where did the anti-urbanists go wrong? By destroying the prevailing idea of the city and the street, they turned away from a model that had proven its efficiency and worth over five millennia – and continues to perform well, in thousands of places, for millions of people worldwide. They replaced it with an anti-urban experiment that didn't work in many ways. They did not foresee (or did not care about) the drastically negative impacts of the "drive-in utopia," from destroyed land ecology to increased crash risk, from oil wars to global warming, and not least, the negative health, financial cost and quality-of-life impacts of sprawl.

Therefore, the proposed replacement for functional classification is a sustainable network classification that supports sustainable cities. The sustainable city is a walkable city.

SUSTAINABLE TRANSPORT

The most popular definition of sustainability comes from the Brundtland Commission: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." A commonly-used framework is the Three Pillars of social, environmental, and economic sustainability. For transit applications, this framework was agreed to in the "Toronto Protocol" at the 1999 UITP World Congress in Toronto. UITP (2004) has a fine introduction to the topic.

A sampling of indices that may be used to evaluate the sustainability of transportation include:

Environmental – Energy consumption, resource use in land and raw materials per capita (ecological footprint), emissions and pollution per capita as well as regionally and globally. Land impacts (species habitat, nonpoint runoff, watershed degradation, heat island effect).

Social – Access to jobs, retail, services, leisure, religious and civic uses. Comfort, convenience and crash risk. Environmental justice. Access to scenic / recreational land. Loss of prime and local agricultural land. Potential disruptions due to Peak Oil and other energy shortages; strategic dependence on hostile foreign nations. Societal disruptions and security threats resulting from global warming.

Economic – Energy efficiency, costs of vehicle ownership, operation and maintenance. Location efficiency. Costs of crashes, costs of congestion, cost-benefit analysis, environmental externalities. Subsidies in all forms including parking. Municipal, county, state and federal outlays (school buses, mail service, utilities, paving, emergency services, etc.).

META-PROPERTIES OF THOROUGHFARE CLASSIFICATION SYSTEMS

In addition to content, the organization and presentation of a thoroughfare classification system is important. It affects how the system is explained and understood, and what aspects are prioritized. That in turn affects how the system is put into practice.

The functional classification system and alternative systems are built around one or more *primary relationships*. For instance, the primary relationship of functional classification is mobility to land access. This makes the system easy to remember and encodes the entire thing in a single diagram. Primary relationships are supplemented with *secondary relationships* and principles that furnish supplementary conditions, rules of thumb, modifications, subtleties and so forth. A primary relationship has signifying power, because implied within it is a design and engineering outline for an entire physical landscape.

The great strength and great flaw of functional classification is its simplicity. It is reductive in the extreme, dumbing down 5,000 years of rich urban complexity and variety to just a handful of road types and relationships. Sustainable networks necessarily are more complex, because they include a wider variety of factors interoperating on multiple layers and scales.

Unraveling the reductive and tightly-knotted relationships in functional classification will involve a) decoupling speed from trip length; b) decoupling capacity from trip length; and c) decoupling capacity from land access.

EXISTING EXAMPLES

ARTISTS

The Arterial Streets Towards Sustainability (ARTISTS) project was an EU-sponsored initiative completed in 2004. It proposed a new functional classification system that recognizes all users and uses of streets, not just vehicular movement. A supporting research paper, A First Theoretical Approach to Classification of Arterial Streets (Marshall 2002) is required background reading for anyone concerned with thoroughfare classification systems. It is a comprehensive review of all thoroughfare classification systems that have been imagined or implemented.

The ARTISTS classification has two axes, link status and place status. Each axis is keyed to the same

geographical scale. Link status is the relative significance of a street section as a link in the network, based on its geographical scale. Routes of national significance have more status than routes of city significance, and so on. Routes of local significance have the least status.

Place status is the relative significance of a street section as an urban place, based on its geographical significance and specialization of its land uses. Places of national significance have more importance than places of city significance, and so on.

ARTISTS street classification table

Link status \ Place status	Local	Neighbourhood	District	City	National
National	Ie	Id	Ic	Ib	Ia
City	IIe	IId	IIc	IIb	IIa
District	IIIe	IIId	IIIc	IIIb	IIIa
Neighbourhood	IVe	IVd	IVc	IVb	IVa
Local	Ve	Vd	Vc	Vb	Va

Legend:
- Arterial roads/ways
- Arterial streets
- Non-arterial roads/ways
- Non-arterial streets

Figure 5: ARTISTS classification matrix. Credit: ARTISTS

The ARTISTS system begins with the proposition that people, not vehicles, should be put first in consideration of street design. However, the system's primary relationship is mostly concerned with accommodating all types of thoroughfares – both people-oriented and traffic-oriented. It provides no guidance about what is the most sustainable or desirable balance, leaving that determination to the political process. In the ARTISTS system, considering people before vehicles, and considering modes of travel other than private vehicles, are secondary relationships.

Advantages: The advantages of the ARTISTS system are several. It recognizes that thoroughfares are places in and of themselves. It puts links and places on an equal footing. It is an extension of existing classification systems, and a system that includes all options may have a better chance of being accepted by the engineering profession. It creates equal roles for engineers (specifying road function) and planners (specifying place function). By recognizing the political aspect of design, it justifies greater public participation.

Disadvantages: A major disadvantage of ARTISTS is that it does little to *encourage* sustainable thoroughfares. There is little mention of connectivity, efficiency, compact development, context or walkability. It elevates the status of national and citywide routes, which could perpetuate a focus on long-distance commuting instead of in-town development that minimizes vehicle-miles traveled. Local places have the least status, which means they lose in the battle between traffic and place. That may not be in the best interests of neighborhood residents.

In the U.S., the most likely outcome of the ARTISTS approach is a continuation of the status quo. In the U.S., many professional organizations and guidebooks give lip service to sustainable transportation, flexibility in design, consideration of context and all users, and so on – but the vast majority of facilities being planned and built are totally auto-oriented. If we want a system that gives stronger support to sustainable networks, we must look elsewhere.

As Lucy Gibson of Smart Mobility put it, "We need to think more about the goals of how much traffic we want on the street, rather than what the model says we have to accommodate on the street."

Manual for Streets

The Manual for Streets was released in the UK in 2007. It is a government document that provides technical guidance for the design of livable, walkable streets such as residential and mixed-use streets. It employs a slightly modified version of the ARTISTS primary relationship, supplemented with a full book's worth of secondary principles.

Here, place status is the relative significance of a thoroughfare "in human terms," considering especially local distinctiveness, visual quality and ability to encourage social activity. Movement status is a combination of traffic capacity (volume) and geographical scale of destinations served.

Figure 6: Manual for Streets primary relationship. Image credit: UK Department of Transport / Andrew Cameron, WSP and Bob White, Kent County Council

The Manual for Streets recommends the flexible application of a user hierarchy, in which pedestrians are considered first, then cyclists, public transport users, service vehicles, and lastly, other motor traffic. It recommends well-connected street networks, design in harmony with local context, and a full range of pedestrian-oriented design strategies for placemaking. It also recommends considering patterns of movement, and how they are affected by the street network pattern.

The Manual for Streets is one of the best comprehensive frameworks for transportation networks. It relies on general principles and flexible guidelines more than strict specifications and rigid categorization (Figures 7 and 8).

Advantages: Compared to ARTISTS, the definition of place status is more objective and results-oriented. The secondary guidance is generalized and flexible; it mentions network properties like connectivity, and furnishes detailed explanations of pedestrian-oriented thoroughfare design.

Figure 7, right: Manual for Streets user hierarchy. Figure 8, below: Manual for Streets pedestrian and bicycle planning guidance. Image credits: UK Department of Transport

Consider first	Pedestrians
	Cyclists
	Public transport users
	Specialist service vehicles (e.g. emergency services, waste, etc.)
Consider last	Other motor traffic

	Pedestrians	Cyclists
Consider first	Traffic volume reduction	Traffic volume reduction
	Traffic speed reduction	Traffic speed reduction
	Reallocation of road space to pedestrians	Junction treatment, hazard site treatment, traffic management
	Provision of direct at-grade crossings, improved pedestrian routes on existing desire lines	Cycle tracks away from roads
Consider last	New pedestrian alignment or grade separation	Conversion of footways/footpaths to adjacent-* or shared-use routes for pedestrians and cyclists

* Adjacent-use routes are those where the cyclists are segregated from pedestrians.

Disadvantages: Like ARTISTS, the primary relationship is focused on determining a win-lose contest of pedestrians and vehicles. Movement status defines longest routes as having highest status, which may not match actual patterns of demand or neighborhood needs. The format of the descriptive secondary material constitutes an excellent design manual but is too diffuse and qualitative to work as a classification system. It might be improved if its design recommendations could be systematized into an easily-remembered framework.

SmartCode

The rural-to-urban Transect is such a framework. This concept envisions walkable, built environments on a spectrum from least intensively urban to most intensively urban. The idea dates back centuries, but it recently has been systematized by the planning firm Duany Plater-Zyberk & Co. and is the kernel of the free, open-source SmartCode zoning ordinance.

The rural-to-urban spectrum may be divided into Transect zones for ease of administration; for example, there are six zones in the base SmartCode. Each zone is an immersive environment, where the design elements of walkability are coordinated and harmonized according to time-tested principles and local context. Historically derived design principles ensure that streetscapes are safe and attractive for people on foot. Local context ensures that local heritage, preferences and character are reflected in the patterns of development. Some of the main goals are to maximize the convenience and comfort of walking; to make public spaces lively with activity; and to create or support a wide diversity of living environments for a variety of market preferences.

Note: All requirements in this Table are subject to calibration for local context.

d. THOROUGHFARES	T1 NATURAL ZONE	T2 RURAL ZONE	T3 SUB-URBAN ZONE	T4 GENERAL URBAN ZONE	T5 URBAN CENTER ZONE	T6 URBAN CORE ZONE	SD SPECIAL DISTRICT
Highway	permitted	permitted	permitted	not permitted	not permitted	not permitted	
Boulevard	not permitted	not permitted	permitted	permitted	permitted	permitted	
Avenue	not permitted	not permitted	permitted	permitted	permitted	permitted	
Commercial Street	not permitted	not permitted	not permitted	not permitted	permitted	permitted	
Drive	not permitted	not permitted	permitted	permitted	permitted	permitted	
Street	not permitted	not permitted	permitted	permitted	permitted	not permitted	
Road	permitted	permitted	permitted	not permitted	not permitted	not permitted	
Rear Lane	permitted	permitted	permitted	permitted	not permitted	not permitted	
Rear Alley	not permitted	not permitted	permitted	required	required	required	
Path	permitted	permitted	permitted	permitted	not permitted	not permitted	
Passage	not permitted	not permitted	permitted	permitted	permitted	permitted	
Bicycle Trail	permitted	permitted	permitted	not permitted *	not permitted	not permitted	
Bicycle Lane	permitted	permitted	permitted	permitted	not permitted	not permitted	
Bicycle Route	permitted	permitted	permitted	permitted	permitted	permitted	

* permitted within Open Spaces

Figure 9: SmartCode table of thoroughfares. Adapted from SmartCode version 9.2, Table 14, "SmartCode Summary" (smartcodecentral.com). Credit: Duany Plater-Zyberk & Co.

Different thoroughfare types are allocated to various Transect zones. Thoroughfares are defined in terms of number of lanes, lane width, types of on-street parking, target speed, and other properties. An important aspect of Transect zones is that they usually encompass an area larger than the streetscape

of a single thoroughfare – they usually include the surrounding blocks. Thus context is keyed to local neighborhood characteristics.

The classification implied in the SmartCode (but not stated explicitly) is mostly related to roadway vehicle capacity. Therefore the primary relationship of the SmartCode is: vehicular capacity to place context.

Advantages: Systematizes walkable design principles in an easily remembered framework; highlights diversity of built environments and local context. Useful for designers because dimensions are specified but also are intended to be customized. Establishes network connectivity within neighborhoods via maximum block sizes.

Disadvantages: Reinforces the idea that the purpose of wider thoroughfares is faster auto traffic. Does not address priority for transit or bicycle modes. No inter-neighborhood or city scale guidance for network configuration.

The Transect framework has been incorporated into the manual Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities (Institute of Traffic Engineers, 2006). That document supplements functional classification with pedestrian-oriented thoroughfare types organized by Transect zones. The manual has been critiqued (Steuteville, 2007) and a revision is scheduled to be released in mid- to late-2009. Early rumors indicate the revised version will discard functional classification.

SUSTAINABLE NETWORK CLASSIFICATION

A sustainable network classification ideally will do several things.

- Actively encourage sustainability (as defined previously in the sustainable transport section); do not support unsustainable network patterns and operations.

- Be concise, easy to remember and easy to explain.

- Address a range of scales, a range that is at least as wide as that covered by functional classification.

- Incorporate advanced knowledge about network function and best practices in network planning.

To reach these goals, a sustainable network classification is proposed. The classification has three primary relationships, each applying to a different scale. The three scales are block scale, neighborhood scale, and city scale. This allows each relationship to focus on the factors most relevant to its scale, without unnecessarily confusing factors from different scales or combining them inappropriately.

In addition, there are two imperatives that should apply in almost all contexts.

One, the sustainable network has high connectivity throughout. Connectivity can be defined as the combination of route directness and route choice. Route directness means the routes from point to point are direct. It can be expressed as the ratio of straight-line distance to shortest-path travel distance. The closer to a 1:1 ratio the better. Route directness entails small blocks and few or no dead ends, and eliminates long detours that discourage walking. Route choice means there are multiple, rela-

tively direct routes from point to point. Route choice reduces network bottlenecks and provides the perceptual variety that encourages walking.

Two, sustainable networks have high place accessibility throughout. Place accessibility is the ability of people to get to their activities and destinations. To have high place accessibility, people must be in close proximity to a wide mix of uses and activities, such as jobs, shopping, services, education, religious, civic and recreation. High place accessibility is enabled by networks that let people quickly and easily walk, bike, and ride transit to their destinations. Areas with good place accessibility can be livable and economically competitive as well as efficient; excessive mobility is not a requirement.

BLOCK SCALE

The block scale is the scale of the immediate environment – what the person on the street experiences. This scale addresses design elements that make a place livable, such as porches, welcoming shop fronts, active frontages, street trees, thoroughfare size, and the proportion of the right-of-way devoted to the thoroughfare. The sustainability of thoroughfares at this scale is closely related to the efficient use of space.

Figure 10: Amount of space required to transport the same number of passengers by car, bus or bicycle. Photo credit: Press office, City of Münster, Germany
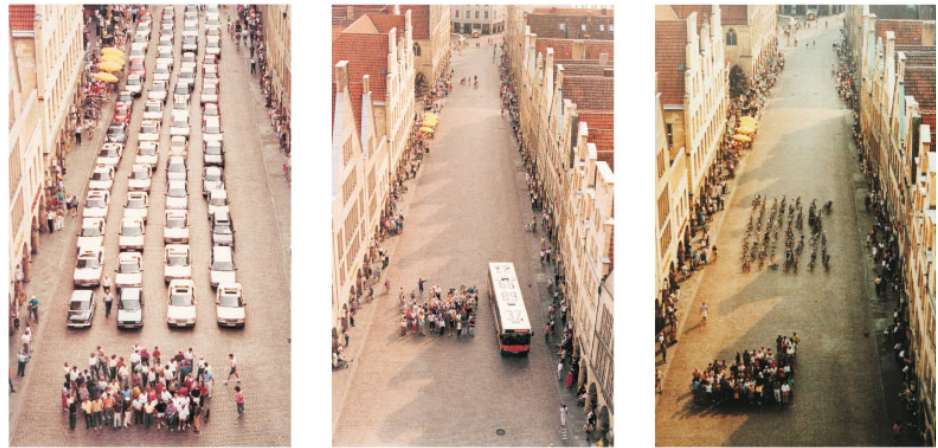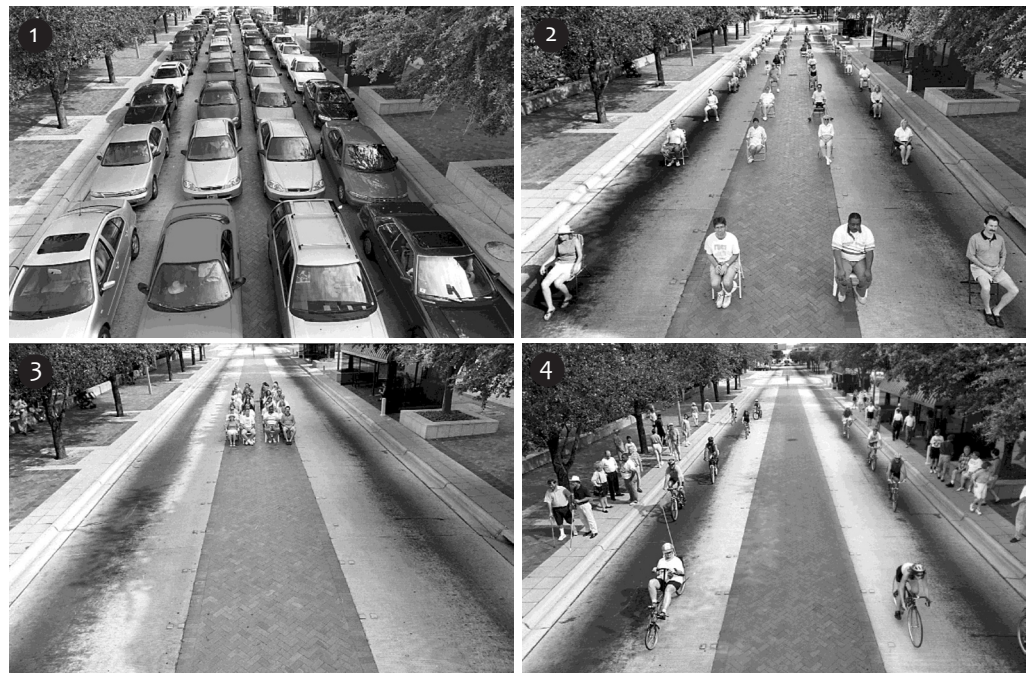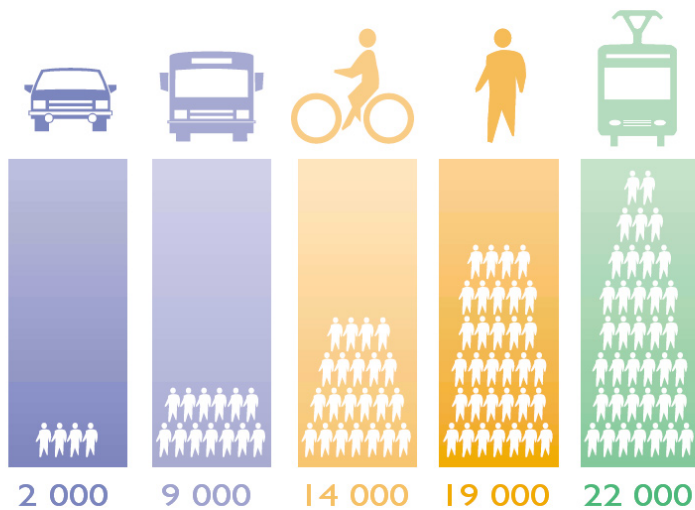

Figure 11: A group of 40 people (1) in their cars, (2) seated at car spacing, (3) seated at bus passenger spacing, (4) as pedestrians and bicyclists. Photo credit: Phil Sheffield, Tampa Tribune

Person Capacity per Lane-Equivalent

| 2 000 | 9 000 | 14 000 | 19 000 | 22 000 |

Number of people crossing a 3.5-meter-wide space in an urban environment during a one-hour period.

Figure 12: Space efficiency of various travel modes. Source: *Ticket to the future: 3 Stops to Sustainable Mobility.* UITP, International Association of Public Transport, Brussels, 2003, based on Botma & Pependrecht, Traffic operation of bicycle traffic, TU Delft, 1991

The efficient use of space, in the form of compact, mixed use development with human-scale thoroughfares, is a necessary design aspect of safe and attractive walking environments. Space efficiency reduces land consumption and runoff pollution. Travel modes that use space most efficiently also use energy more efficiently. Space-efficient modes support more "location-efficient" housing where the cost of housing plus transportation is less than at the suburban fringe.

The space efficiency of travel modes is measured in terms of person-capacity, which is the number of people that can traverse a given space over a given time period. This measurement encompasses multimodal capacity and also includes pedestrian capacity. It is a means of making all modes comparable on a universal scale. It prioritizes rail, walking and bicycling (Figure 12).

The person-capacity to place context relationship is the primary relationship at the block scale (Figure 13). When person-capacity is asociated with walkable place context, the resulting matrix optimizes the combination of network and place, prioritizing the operation of sustainable travel modes in livable, safe and attractive environments. The SmartCode Transect is adapted to this matrix because it is systematic and well-defined, is coming into widespread use, and is supported by a growing body of literature and case experience. However, other transect- or context-based classification systems may work equally well.

There are a number of reasons for combining all modes into a person-capacity metric.

- For policy, it places all modes on an equal footing in one framework in order to set priorities and make cost-benefit evaluations. It allows all modes to be evaluated by the same standard.

- For professional guidance, it breaks down the silos that usually separate each mode, each with its own specialist community with standards and practices that do not interoperate. It reaches across disciplines, giving a holistic perspective and a greater focus on the big-picture systems view, i.e., overall efficiency, sustainability and livability.

- It can be flexible. Planners can break out modes as needed, resulting in models that may be similar to existing practices. The difference is the awareness that such broken-out models are fragments of the whole. They will be re-incorporated into the complete network as is appropriate in the planning and operating processes.

Sustainable Network Classification: Block Scale

Person-Capacity (persons per lane-equivalent per day)

High / High priority

- High Speed Rail
- Metro / Subway
- Multi-Way Boulevard w/ Tram
- Busway Avenue
- Pedestrian Priority Street
- Main Street
- Parkway w/ Bikeway
- Residential Shared Space
- Dedicated and/or Specialized Transport Facilities (Rail, Water or Road)

Low / Low priority

Place Context rural to urban

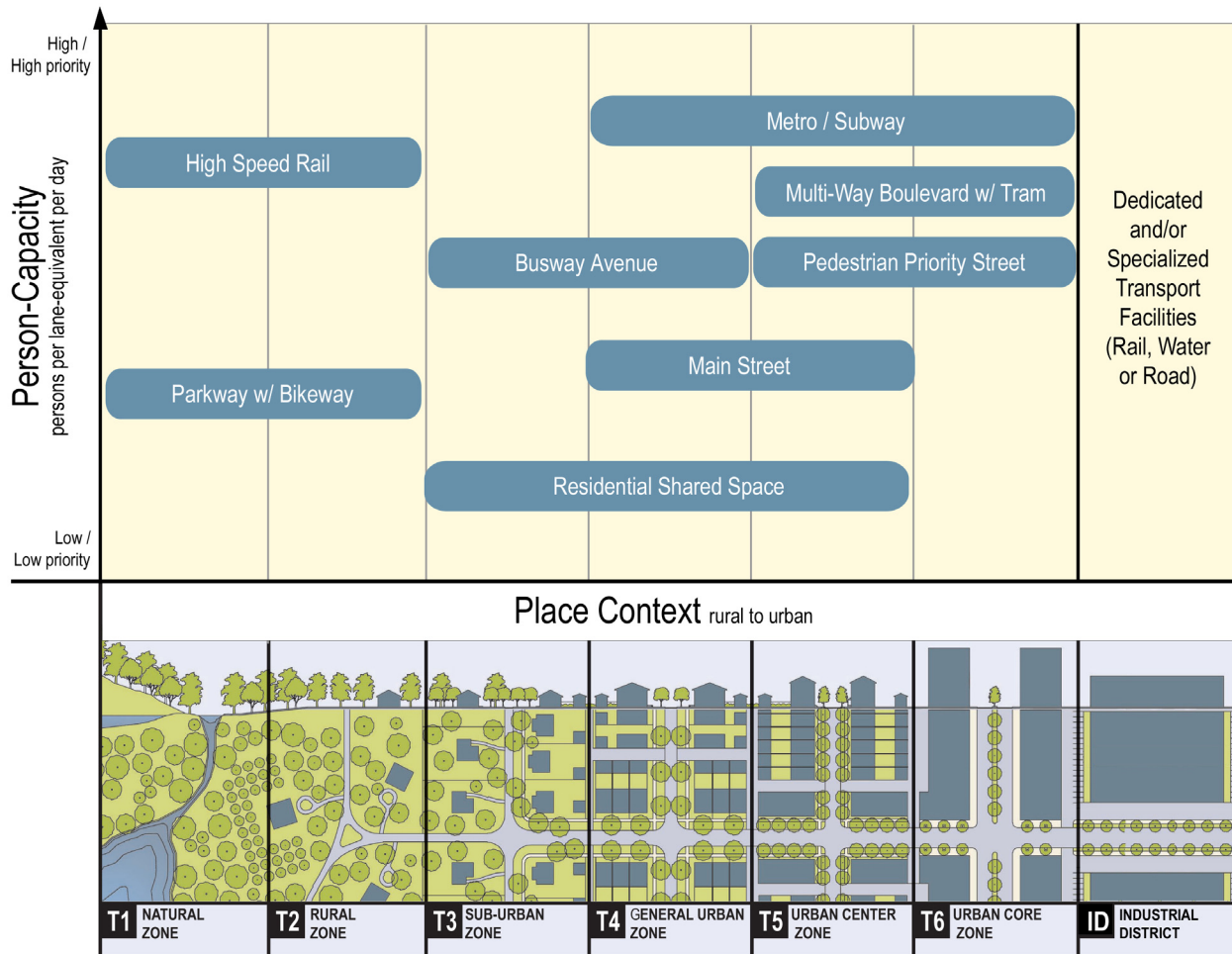| T1 NATURAL ZONE | T2 RURAL ZONE | T3 SUB-URBAN ZONE | T4 GENERAL URBAN ZONE | T5 URBAN CENTER ZONE | T6 URBAN CORE ZONE | ID INDUSTRIAL DISTRICT |

Figure 13: The sustainable network classification block scale relationship is: person-capacity to place context. The matrix shows only a representative selection of network facilities, not a complete inventory. Chart matrix by Laurence Aurbach. Transect Zone illustration adapted from *SmartCode v. 9.2*, SmartCode Central

Advantages: Person-capacity plus a context- or transect-based framework yields a holistic perspective that better addresses efficiency and livability.

Disadvantages: A homogenizing focus on person-capacity may obscure the unique, qualitative benefits of each mode. The inclusion of place context involves additional layers of planning and politics, which makes network planning more complex and time-consuming.

MODE NETWORKS AND PLACE CONTEXT

Mode networks are the building blocks of the complete network. At some points in the planning process individual mode networks will be considered; at other points the complete network will be the focus. For planning and engineering purposes, mode networks may need to be considered on their own, or in an iterative manner that considers how mode networks plug into and affect the complete network.

A brief review follows of each mode network and its salient relationships to place context.

Boulevards are grand city streets carrying heavy volumes of traffic, while still providing an attractive environment for walking and for cycling. Street trees, wide footpaths and a green median are essential parts.
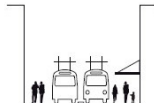
High quality walking link with the occasional ligh trail or bus passing through. A low level of noise and a busy atmosphere of many people visiting and promenading are distinct trademarks. Cycling is a natural part of these streets.

Pedestrian priority streets prioritize walking. No kerbs have been installed and it is more a negotiation process, than a right of way. These types of streets hold strong restrictions on vehicular traffic in terms of turning options and driving directions. Thus the level of vehicular traffic is low and space is gained for other people activities.
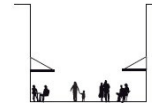
Pedestrian streets are often part of a larger network of more or less pedestrianised streets and squares. Together they form a network of various experiences and possibilites for play in a calm and safe environment. The most succesful of these types of streets are the ones with a multitude of activities extending into the evening.

BOULEVARD | PUBLIC TRANSPORT STREET | PEDESTRIAN PRIORITY STREET | PEDESTRIAN STREET

24 metre wide footpaths are essential parts of Champs-Élysées, which have a strong green profile and a clear division between transport zones and zones for street furniture etc.
Champs Elysée, France
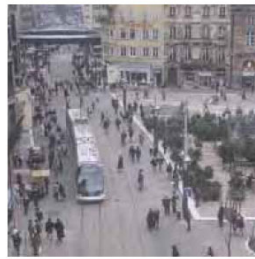
A homogeneous paving unifies the street with the square and indicates a high level of shared space, where pedestrians are invited to cross at their convenience.
Strasbourg, France

The one levelled pavement is divided into patterns defining the different zones for movement and for recreational purposes.
Strædet, Copenhagen, Denmark

Pedestrian streets are distinct gathering points for a number of people, both locals and visitors.
Strøget, Copenhagen, Denmark

Wide footpaths and distinct street trees frame the pedestrian space. A green median provides a safe retreat.
Copenhagen, Denmark

Grass defines the zoning of the street in a public transport part and a pedestrian part.
Barcelona, Spain

Shared surface with attractive paving and public benches.
New Road, Brighton, England

Wall to wall paving defines the streetscape and sends a strong signal of pedestrianisation. Here kids can run freely to play and a multitude of activities can take place. *Bilbao, Spain*

Figure 14: Gehl's typology of pedestrian thoroughfares, from the public space plan for Sydney, Austrialia (2007) which is a leading example of pedestrian network planning. Image credit: Jan Gehl Architects

Pedestrian network

The pedestrian network – in this case meaning all public routes that accommodate pedestrians – is the largest network, combining thoroughfares and pedestrian-only facilities. Walking is the primal method of locomotion common to all human beings and is necessarily the most pervasive mode. Pedestrian routes are the most flexible and adaptive, and can range from narrow passages, to standard sidewalks, to broad plazas and promenades.

Gehl (1989) advocates the important concept of "pedestrian stays": standing, sitting and lingering in order to participate in the activities of the public realm. Some examples of public realm activities might include chatting, people-watching, napping, joining an audience, games, sports, parades, performing, exhibits, commercial vending, nonprofit booths and presentations, demonstrating, and speechmaking. Pedestrian stays can be represented by the number of persons present and the duration of their stays, and is a way to measure the goodness of public spaces.

Pedestrian stays are usually considered a place function, not a network function. But there may be useful reasons to categorize them as a network function. They are part of roadside context; gatherings of people attract more people in a positive feedback loop; the presence of more pedestrians and cyclists

decreases crash risk. Pedestrian trips can switch to pedestrian stays in an instant. Through travel is affected by pedestrian stays; linear, directed, through movement mixes with wandering, nondirected "place movement," affecting the operation and space requirements of sidewalks and other pedestrian facilities. This is a topic that deserves more attention and research.

Bicycle Network

Bicycle facilities are often classified according to the safety requirements necessitated by motor vehicle traffic. They include bike boulevards, bike lanes, separated bike lanes, and bike trails. In the sustainable network there is a greater emphasis on livable thoroughfare and network design, which results in safer conditions for bicycling. When thoroughfare design is more livable, drivers receive more cues to slow down and be cautious. When more pedestrians and bikers are on the street, the risk of crashes is lessened – again, because drivers are cued to be cautious. In the sustainable network is it safer for bicycle and motor vehicle traffic to mix, and there is less need for separated bicycle facilities.

Private Vehicle Network

The spatial efficiency of private passenger-vehicle traffic is directly related to vehicle size and passengers per vehicle. Those factors are influenced by policies, market conditions and cultural patterns that are either outside or complementary to transportation network planning. Therefore, the sustainable network carefully specifies the speed and number of lanes of private-vehicle thoroughfares to ensure they are safe and comfortable for pedestrians and bicyclists. This framework is similar to the SmartCode and ITE/CNU frameworks. Many other guidebooks and case studies are available for the design of livable thoroughfares. In addition to those already mentioned, a few free online examples are the Urban Design Compendium, the Mobility and Community Form Tutorial, and Shared Space approaches. From sources such as these, rules of thumb may be developed for thoroughfares that serve motor vehicles:

- No thoroughfare has more than four lanes dedicated to private auto through traffic; thoroughfares generally are two-way.

- At least half of the right-of-way width is dedicated to pedestrian space, which includes sidewalks and public frontages, on-street parking, and (in the case of multiway boulevards) very-slow-speed side lanes and medians between side and center lanes.

- Generally recommended target speed for vehicular traffic is 20-30 mph.

- Small blocks are the rule in all walkable areas (250-450 feet; may be shorter in carfree areas).

- Limited-access freeways and highways have no place in nonindustrial, built-up areas.

For project evaluation, the common "level of service" metric is intended to accommodate unlimited growth in private auto traffic, which is counterproductive in terms of sustainability, cost-benefit analysis and long-term functionality. It may be replaced with sustainability-oriented alternatives such as the "automobile trips generated" metric proposed by the San Francisco County Transportation Authority (2008).

These guidelines (and indeed the entire sustainable network concept) often provoke objections that congestion will be exacerbated and lengthy delays will appear, making vehicular travel excessively costly, inconvenient and inefficient. These objections are discussed in the "Congestion" section of this essay.

Freight Network

Since freight does not carry passengers, the person-capacity metric does not apply. A volume-based metric may be a suitable alternative; for example, cubic feet per lane-equivalent per day.

Efforts to make freight movement more sustainable involve shifting from trailer-truck freight to rail and water modes, as well as smaller, more efficient freight vans and trucks. Some municipalities have experimented with providing more multimodal capacity and flexibility; terminals and warehouses in centralized locations outside of residential areas; policies for time-shifting to off-peak; and pooling resources for more efficient operations (e.g., city logistics). Congestion management and transportation demand management can reduce the costs of delay and make delivery times more reliable. The EU's CITY FREIGHT project reviewed many of these strategies and found there was no universal solution; rather, various strategies worked best when chosen for and tailored to specific needs and applications.

Transit Network

Different types of transit have different spatial requirements and affect the design of thoroughfares in different ways. Transit can be mixed with private motor vehicle traffic or separated in dedicated lanes. The separation can be strengthened with paving treatments, raised curbs, medians, and other barriers. Transit can be further separated from the thoroughfares by going underground or up above on elevated routes. Tunnels and elevated facilities can be extremely costly, and mass transit is the most efficient use of the limited space they have available. Sustainable networks will also prioritize the dedication of surface lanes to transit so that grade-separated facilities are less needed.

Green Network

Green networks do not serve much in the way of human transportation, other than bike paths and walking trails. But they are essential for environmental and human well being. Green networks in the sustainable network classification are nature preserves that furnish significant ecological services, including species protection, wildlife migration, aquifer protection and recharge, and air filtration and purification.

Sports fields, lawns, landscaping, industrial agriculture and the like are not part of green networks. They are important for recreational, agricultural or aesthetic purposes but do not provide the significant ecological functions. The interweaving of transportation networks and green networks can be a tricky balance; some guidelines are proposed in the City Scale section of this essay.

NEIGHBORHOOD SCALE

The neighborhood scale primary relationship is based largely on the field of Space Syntax. Space Syntax is a type of network analysis that treats street networks in an abstract and mathematical way. It starts with the premise that the configuration of street routes – how streets are arranged in relation to each other – has psychological and social effects that influence the way cities function. Street route configuration affects the flow of pedestrians and vehicles, the location of activity centers, and other social phenomena.

Space Syntax tools measure things like: How many corners must be turned to get from one street segment to another? How many streets intersect with a given street segment? When traveling the shortest routes between various places, which street segments are traversed most often? In walkable urban

environments where land uses are relatively free to develop according to demand, Space Syntax methods accurately model 60 to 80 percent of pedestrian traffic.

As a broad generality, one could say that Space Syntax measures *network accessibility*. Accessibility has many different meanings in the field of land and transportation planning. In this case, the definition of network accessibility is the ease with which one can travel from given thoroughfare segments to other thoroughfare segments.
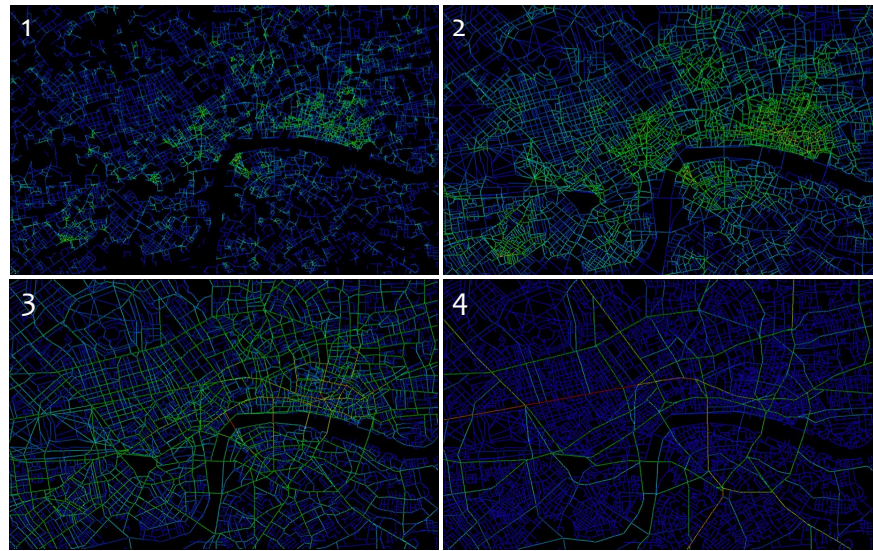

Figure 15: London network accessibility. The identical area of London evaluated by the "angular choice" method at four different scales. 1) Local scale, 400 meter radius; 2) Intermediate-short scale; 3) Intermediate-long scale; 4) City scale, 10 km radius. Images courtesy Noah Raford, Space Syntax Limited

The accessibility of thoroughfares is evaluated at a variety of scales. A thoroughfare segment may be highly accessible at the local scale, but not at the metropolitan scale. Or it may be highly accessible at several scales (Figure 15).

In addition to Space Syntax, a variety of methods can be used to evaluate network accessibility, including: standard GIS measures, such as pedestrian route directness, block size, and effective pedestrian shed; traffic demand modeling, including factors such as target speed, signal priority, land uses; and agent-based modeling, which simulates the actions and interactions of many individuals in a network. A combination of some or all of these methods will give a good picture of network accessibility.

Movement sensitivity is the degree to which a land use needs people traveling by for the purposes of

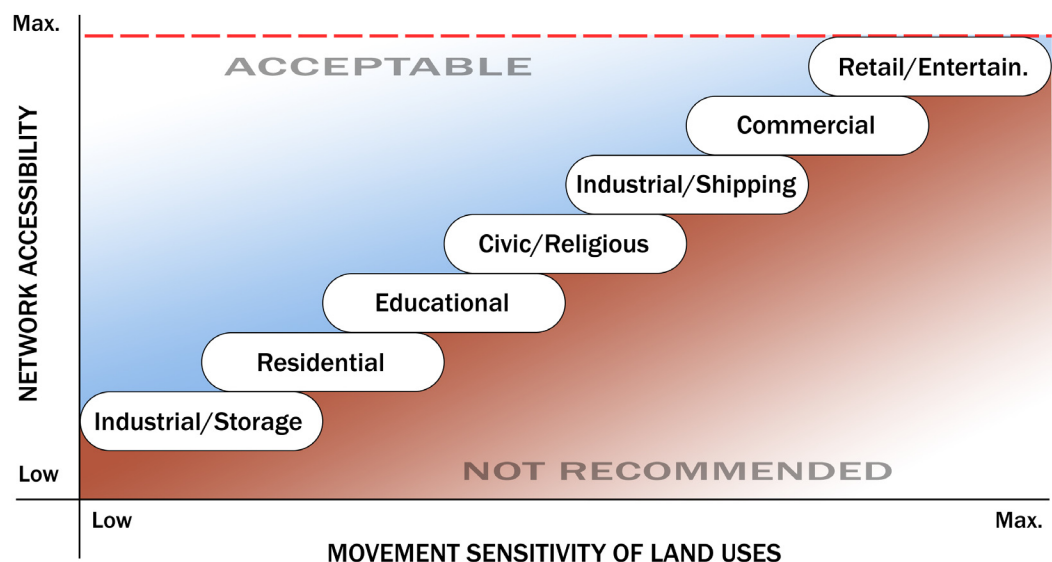## Sustainable Network Classification: Neighborhood Scale

Figure 16: The primary relationship on the neighborhood scale is: network accessibility to land use movement sensitivity. The land use movement sensitivity rankings shown are broad estimates only and have yet to be verified and refined.

user access, functionality, and visibility (Hillier 1996, 2008; Karimi et al. 2007). Figure 16 shows the sustainable network neighborhood scale primary relationship. It shows how land uses with higher movement sensitivity should be located on routes with higher network accessibility. All land uses require a minimum degree of network access to be viable or functional; some more than others. For instance, retail has the greatest movement sensitivity – it depends on high access to customers and high visibility to people passing by. So retail uses should be located on routes with highest accessibility.

Land uses with lower movement sensitivity don't absolutely require high network accessibility. However, it is perfectly acceptable and in some cases recommended for low-movement-sensitivity land uses to be located on high-accessibility routes – especially in the case of mixed-use streets. Those are where commercial, civic and residential uses are present on busy shopping streets. The "acceptable" area in Figure 16 indicates that it is acceptable for any land use to be located on a route that is more accessible than the minimum needed by that land use.

The "not recommended" area in Figure 16 indicates that land uses should not be located on thoroughfares that have less than the minimum needed accessibility. In other words, a land use should not be located on a thoroughfare that doesn't provide sufficient passers-by for its needs.

An example of a plan that carries out this relationship is the redevelopment plan for Jeddah, Saudi Arabia. Figure 17 shows nonresidential land uses (darker shades) concentrated along the most accessible thoroughfares. The areas with a high percentage of residential land tend towards the less accessible thoroughfares.

Figure 17: Plan for the redevelopment of Jeddah, Saudi Arabia, showing proposed land use distribution. Darker areas indicate a higher percentage of nonresidential land uses. Credit: Kayvan Karimi et al. (2007) and Space Syntax Limited

Advantages: This relationship provides a quick and easy rule of thumb for relating land uses and transport routes. It is the structural basis of viable pedestrian- and transit-oriented neighborhoods.

Disadvantages: There is no single, commonly accepted definition of network accessibility. Network accessibility itself can be a difficult concept to understand and explain.

CITY SCALE

The ideal pattern of regional growth has been debated at least since the 19th century. In the 1960s and 70s the focus of the debate sharpened on efficiency and sustainability, and the "Compact City" was suggested to be the ideal. The Compact City redirects all growth into a single urban core, maximizing density while minimizing the consumption of farms, forests and agricultural land. It explicitly counteracted the dominant trend of decentralized suburban sprawl.

Some of the benefits of the Compact City idea have been confirmed by researchers. Cities with higher density and more compact form have much less per capita driving (Newman and Kenworthy, 1999). In existing cities, the trend of sprawling suburban growth causes an explosion in the amount of auto
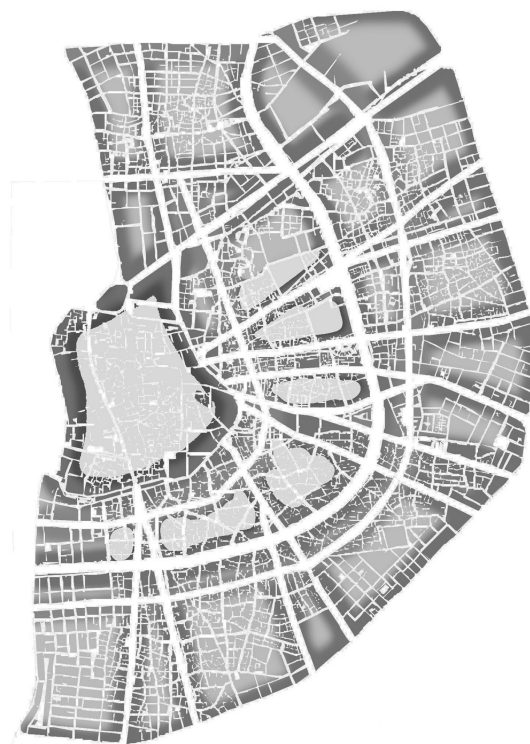
driving; a policy of refocusing growth, mixed use and transit in the urban core will halt that explosion and slightly reduce the amount of driving (Simmonds and Coombe, 2000).

However, over the past 10-20 years the Compact City idea has been critiqued by investigators who argue that an urban pattern with multiple centers is, in some ways, more sustainable (Jencks et al. 1996). Newton's models (1998) (Figure 18) found the compact pattern had low total emissions, but also the highest human exposure to fine particulates.
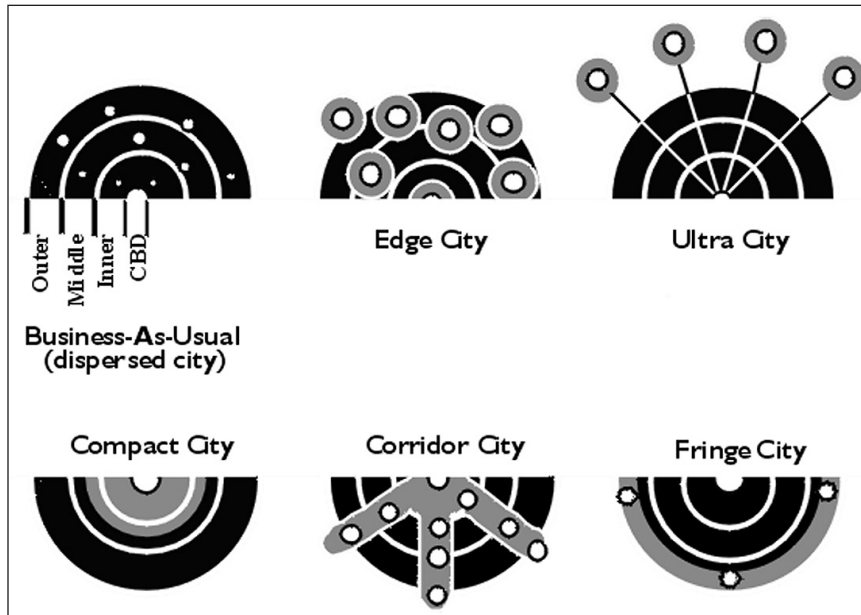

Figure 18: A typology of regional scale development patterns. Image credit: Peter Newton, "Reshaping Cities for a More Sustainable Future" (1998).

Figure 19: Analysis of city scale development patterns shows that focusing growth on high-capacity transit nodes has the greatest CO2 reduction effect. Image credit: Eliot Allen, "Cool Spots"

The lowest exposure to air pollutants was in the corridor pattern, where growth is focused on transit corridors connected to the city center. More recent modeling has yielded similar results (Martins et al., 2007). Polycentric or transit corridor patterns may also provide better access to recreational parks and urban agricultural land, can allow more continuous greenbelts and green corridors for wildlife habitat and riparian protection, and can reduce the urban heat island effect.

Another important element of settlement structure is the location and configuration of centers. Mature, fully developed towns and cities have multiple, overlapping subareas and centers. This creates an interrelated, multilayered ecology of urban environments, a condition that Hillier (2008) calls "pervasive centrality."

> Cities in general – and not just "organic" cities – self-evolve into a foreground network of linked centers at all scales, from a couple of shops and a café through to whole sub-cities, set into a background network of largely residential space.
>
> Good cities, we suggest, have pervasive centrality in that centrality functions diffuse throughout the network. The pattern is far more complex than envisaged in theories of polycentrality. Pervasive centrality is spatially sustainable because it means that wherever you are you are close to a small center and not far from a much larger one.
>
> – Hillier, Using Space Syntax to Regenerate the Historic Centre of Jeddah

The debate between monocentric and alternate patterns is still continuing. Perhaps there will never be a universal answer, because so many outcomes depend on particular conditions and contexts. However, there is broad agreement is that standard suburban sprawl is unsustainable, and that a regional development pattern of concentrated settlements and centers, combined or interwoven with natural preserves and green corridors, is the most sustainable (Newman and Kenworthy, 1999; Williams, 2004).

Most ecological systems thrive in larger, contiguous preserves and corridors, and even the most minimal riparian corridors need to have a certain width and continuity to control water pollution and prevent erosion. At the same time, the assemblage of urban blocks weaves a "continuous urban fabric," which is a necessary condition of walkable urban environments, and which encourages an active street life and public realm. The sustainable network classification should help resolve contesting human and ecological needs for contiguous, connected networks.

Sustainable Network Classification: Settlement Scale and Network Interrelationships

Settlements

- Settlements are nodal, compact and concentrated.
- Settlements may be standalone, overlapping or nested.
- The characteristics of settlements and centers are influenced by the larger settlements and centers they are a part of.

Centers

- Settlements have centers that may be standalone, overlapping or nested.
- Centers are characterized by clusters of highly accessible thoroughfares.
- The coarse-grained location of centers is related to the city-scale accessibility of routes. The fine-grained distribution of land uses within a center is related to the local-scale accessibility of routes.

Thoroughfare networks

- Thoroughfare networks at all scales are contiguous, well connected and pedestrian oriented.
- The smallest scale network is the basis for all larger scale networks.
- The larger the network scale, the more widely spaced apart are the routes.
- The larger the network scale, the more continuous and direct are the routes over longer distances.
- The largest scale street networks are not necessarily composed of the highest capacity thoroughfares.
- Longer distance traffic tends to use larger scale thoroughfare networks, although local and intermediate distance traffic also uses large scale thoroughfare networks.

Bus and rail networks

- Bus and rail networks at each scale are aligned and coordinated with the centers and highly accessible thoroughfares of that scale.
- Bus and rail networks of different scales are coordinated to feed into each other.

Pedestrian and bike networks

- Pedestrian and bike networks are based on the thoroughfare and green networks. Bike networks may be routed on or parallel to the most accessible thoroughfares.

Green networks

- As settlement scale increases, the area and contiguity of nature preserves associated with each scale increases. This only applies to settlements that are not standalone.
- Smaller-scale green networks do not comprise larger-scale green networks, but ideally they are connected.

Green network crossings

- The wider the nature preserve, the greater the spacing between routes that cross the nature preserve.

Figure 20: The city scale concept: Network interrelationships are organized by settlement scale. The generalized, schematic diagram does not represent a model pattern or actual place.

At the city scale, the sustainable network has multiple relationships between settlements, centers, different networks and different scales. The classification uses settlement scale to organize and present a nexus of interrelationships. Figure 20 includes a concise list of the key multi-scale relationships. A more detailed explanation of the list follows.

Settlements

■ Settlements are nodal, compact and concentrated. The size of a neighborhood is based on a 5-10 minute walk from edge to center, which equals a half-mile to one-mile diameter. At the largest scale, Newman (2004) suggests that the maximum sustainable city size is based on a half-hour transit ride from edge to center, a diameter of 14 miles plus or minus two miles. Beyond that size, the inconvenience and inefficiencies of travel begin to outweigh the benefits of citywide access.

■ Settlements may be standalone, overlapping or nested.

■ The characteristics of settlements and centers are influenced by the larger settlements and centers they are a part of. For example, a city scale center may have the same size and population as a group of towns, but it is different than a grouping of towns. It has more and higher-quality infrastructure and transportation networks than the same number of towns in an ungrouped configuration. Similarly, a neighborhood in a city can and will have a better level of infrastructure and transportation service than a neighborhood by itself surrounded by agriculture (i.e., a rural village).

Centers

■ Settlements have centers that may be standalone, overlapping or nested. Centers, in this context, are concentrations of nonresidential activities – public gatherings, commercial, civic, religious, educational, and others.

■ Centers are characterized by clusters of highly accessible thoroughfares (Stonor, 2008). Porta (2007) suggests that the distribution of centers follows a power law behavior, which means that centers occupy a relatively small percentage of total settlement area.
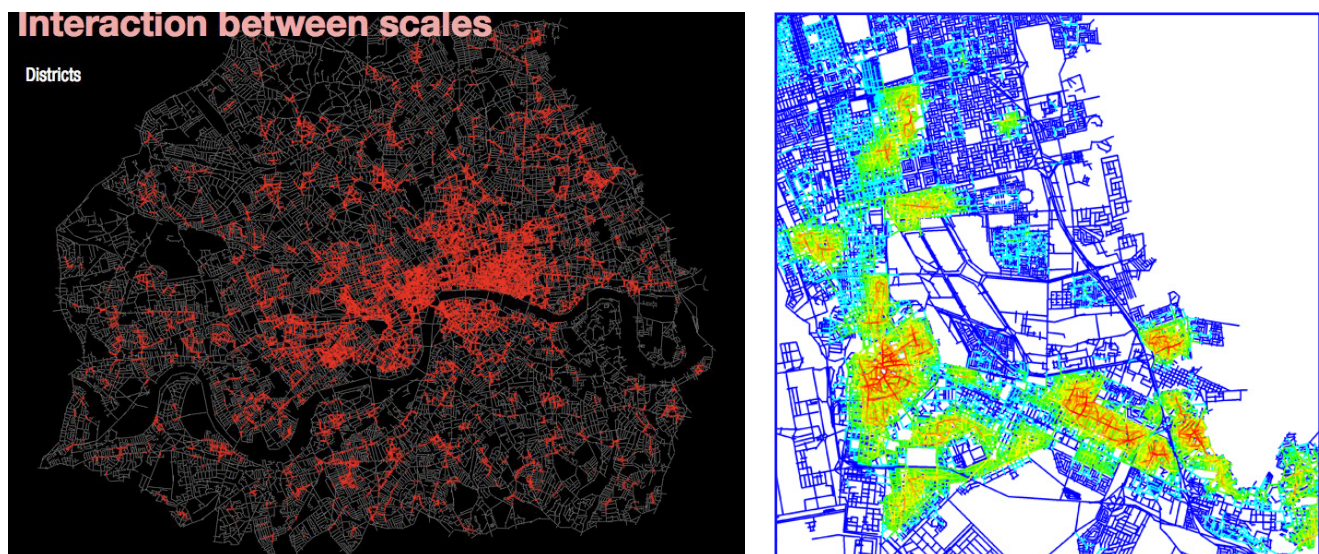
Centers marked by clusters of high accessibility thoroughfares in London, UK (Figure 21, left) and in Jeddah, Saudi Arabia (Figure 22, right). Images courtesy of Noah Raford and Space Syntax Limited

■ The coarse-grained location of centers is related to the city scale accessibility of routes. Centers will tend to be located somewhere near routes that are highly accessible at the city scale. The fine-grained distribution of land uses within a center is related to the local scale accessibility of routes. This reiterates the neighborhood scale primary relationship introduced previously. Both of these relationships have emerged from recent Space Syntax research (Hillier 1996, Greene 2003, Buendia 2007).

Thoroughfare networks

- Thoroughfare networks at all scales are contiguous, well-connected and pedestrian-oriented.

- The smallest scale network is the basis for all larger scale networks. For example, a city scale route is made of segments of the neighborhood scale network. This means that some thoroughfare segments will only serve the smallest scale, and some segments will serve multiple scales.

- The larger the network scale, the more widely spaced apart are the routes. At the neighborhood scale, blocks with a maximum dimension of 250-450 feet are best, assuming car traffic is present. Car-free settlements may have smaller blocks. At the city scale, avenues or boulevards spaced one-half mile apart provide sufficient connectivity so there is no need for large, limited access freeways and highways. The city of Vancouver, B.C., is an example where that pattern functions successfully.

- The larger the network scale, the more continuous and direct are the routes over longer distances. Where there are interruptions to the network, it is the larger scale networks that tend to continue through via bridges, tunnels, and other crossings.

- The largest-scale street networks are not necessarily composed of the highest-capacity thoroughfares. They may be, but the relationship is not absolute. Some segments of neighborhood and town scale routes may have greater demand that requires higher capacity. Some segments of city scale routes might have less demand, so that narrower thoroughfares might be appropriate in those cases. Just because a thoroughfare serves longer-distance traffic does not mean it will experience the most demand, so it should not automatically be the widest.

- Longer-distance traffic tends to use larger-scale thoroughfare networks, although local- and intermediate-distance traffic also uses large-scale thoroughfare networks. One advantage of well-connected networks at a range of scales is less channelization of traffic on large-scale networks. When there are fewer lanes and lower traffic volumes on large-scale thoroughfares, they can be more humane, pedestrian-friendly environments.

Bus and rail networks

- Different transit types have service characteristics that are best suited to different scales: neighborhood scale served by local bus, tram, trolley, streetcar; town scale served by light rail and bus rapid transit; city scale served by metro/subway, commuter rail, and commuter bus.

- Bus and rail networks at each scale are aligned and coordinated with the centers and highly accessible thoroughfares of that scale. The provision of transit itself affects the characteristics of places and encourages nodal patterns of development. In concert with different types of centers (across scales and within various settlement contexts), this can produce a wide variety of transit-oriented developments. Zimmerman-Bergman (2008) reviews several transit-oriented development typologies, showing how scale can influence placemaking and transit planning.
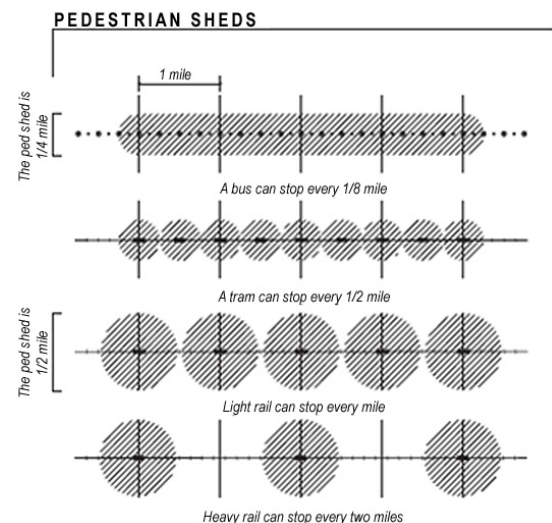
Figure 23: Pedestrian sheds centered on transit stops. Image credit: Duany Plater-Zyberk & Company, *Lexicon of the New Urbanism*

■ Bus and rail networks of different scales are coordinated to feed into each other. As settlement scale increases, the complexity of network layering increases. There are more intra-network transfer points and trans-network nodes. There is a greater variety of surface facilities, where transit may be mixed or separated from other traffic. There may be more 3-D layers (subsurface and elevated transit facilities) with more complex siting and coordination issues.

Pedestrian and bike networks

■ Pedestrian and bike networks are based on the thoroughfare and green networks.

■ Pedestrian networks can include additional facilities like paths, passages, and pedestrian-only streets. Bike networks may be routed on or parallel to the most accessible thoroughfares. Seeking the optimum balance between utility and range, bicycle networks tend to be on the intermediate scale. In sustainable networks, vehicular traffic is less channelized, and thoroughfares are safer and more pleasant for biking, so biking on the street can take place on a greater percentage of the thoroughfare network.

Green networks

■ Green networks exist on a spectrum of scales: on the local scale, small ecological sites and narrow stream buffer corridors; on the town scale, small ecological patches and wildlife migration corridors; on the city scale, large ecological patches, regional nature preserves and wilderness areas.

■ As settlement scale increases, the area and contiguity of nature preserves associated with each scale increases. This only applies to settlements that are not standalone because standalone settlements may be associated with nature preserves of any size. For example, a village might be situated at the edge of a large regional preserve.

■ Smaller-scale green networks do not comprise larger-scale green networks, but ideally they are connected. For instance, a collection of small ecological patches does not constitute a regional scale preserve, although ideally they are connected to regional scale preserves. A collection of minimally buffered streams does not constitute a fully functional wildlife migration corridor, although ideally they are connected to wildlife corridors.

Green network crossings

■ The wider the nature preserve, the greater the spacing between routes that cross the nature preserve. This applies to preserves within settlements and balances thoroughfare network contiguity with green network contiguity. A narrow stream buffer may have crossings every 800-1,200 feet; a wider wildlife migration corridor may have crossings every half-mile, and the widest regional preserves may have crossings two miles apart.

City scale overall

Advantages: Organizes a number of key, interlocking network relationships with one general framework.

Disadvantages: Much more complex than a single relationship; is not represented by a single, easily explained diagram.

CONGESTION

The sustainable network strives for a greater diversity of travel modes and the prioritization of the most sustainable modes. In areas where private auto and truck travel is dominant, this usually provokes protestations that congestion will be exacerbated and lengthy delays will appear, making vehicular travel excessively costly, inconvenient and inefficient.
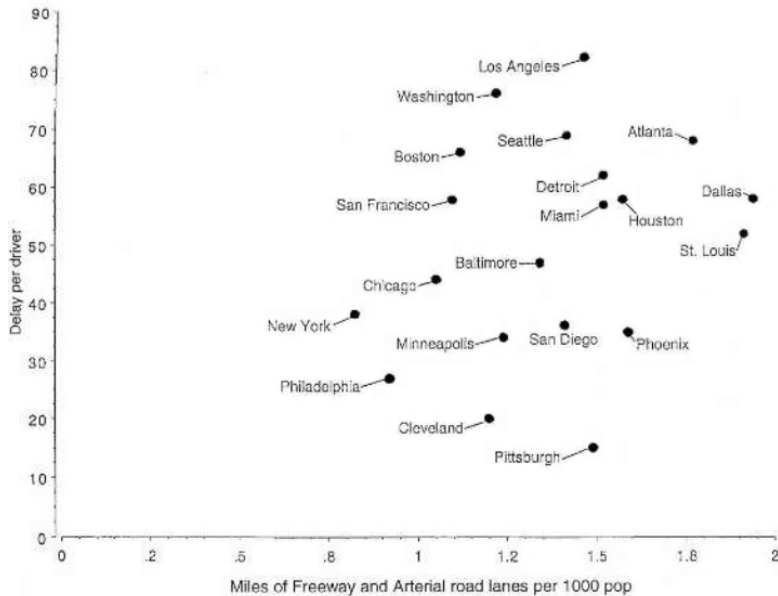

Figure 24: In the 20 biggest U.S. cities, more freeway and arterial lane-miles per capita has zero relationship to less congestion delay per capita. Image credit: Peter Newman

The position in favor of endless roadway expansion is that time is money, speed saves time, and more roadway capacity enables faster auto travel. Faster auto travel saves money and makes a city more prosperous. However, there are a number of flaws in this line of reasoning. In the 20 biggest U.S. cities, there is no relationship between the amount of freeway and arterial lane-miles and delay (Figure 24). Indeed, the three cities with the fewest freeway and arterial lane-miles have less delay than the three cities with the most freeway and arterial lane-miles.

Why is this? Part of the reason is induced or generated traffic. When a major roadway is built, all that free pavement attracts drivers who wouldn't otherwise use the road. Studies show in the short term, doubling capacity causes a 10-70 percent increase in traffic. Over the long term the new roadways attract new development, so that a doubled capacity ends up with a 50-100 percent increase in traffic (Rodier 2004, Ewing and Lichtenstein 2002, Litman 2009). This is the basis for the saying, "We can't build our way out of congestion."
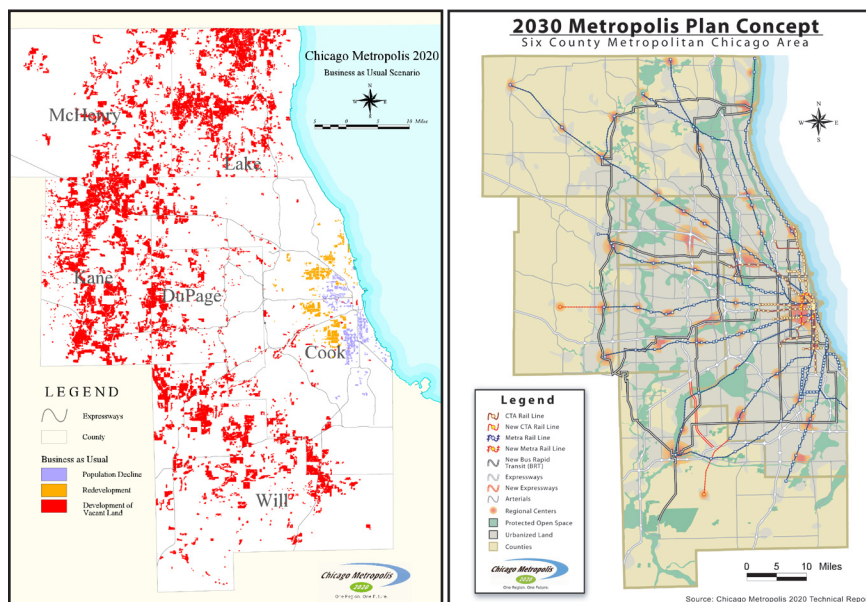

Figure 25: Two future scenarios for the Chicago metro area: sprawling business-as-usual vs. nodal development patterns focused on transit corridors. Credit: Chicago Metropolis 2020

A massive study by the Rand Corporation (2008) of congestion in Los Angeles found that adding roadway capacity was fundamentally unable to reduce peak congestion. Rand recommended that roadway pricing strategies be implemented, along with policies to improve transit, carpooling, biking and walking, and smarter use of the existing thoroughfare network.

A good example of what can be achieved in the U.S. is the Chicago Metropolis 2020 plan. The plan compared two scenarios over the next 20-30 years: business as usual (BAU), meaning more auto-dependent sprawl at the urban fringe, versus a nodal pattern of development focusing growth at infill locations and transit corridors (Figure 25).

The technical report modeled the BAU and 2020 Plan scenarios, both relative to a 1996 baseline. The model showed the 2020 Plan to have far superior congestion performance compared to BAU.

- Time spent traveling: BAU increases 25%, 2020 Plan increases 1%

- Vehicle miles per person: BAU increases 10%, 2020 Plan decreases 12%

- Time spent driving: BAU increases 25%, 2020 Plan decreases 23%

- Congestion delay: BAU increases 77%, 2020 Plan decreases 43%

Goodwin (2004) explains the institutional reasons why big-ticket road building schemes that make exaggerated claims about congestion relief, time savings, etc., win out against simpler, cheaper and more effective solutions. Goodwin notes there is little firm factual evidence of the effects of transport initiatives on economic growth, and what evidence does exist tends to support pedestrian-oriented centers. Meanwhile Litman (2006) analyzed the costs of auto transportation and found that congestion costs are much smaller than crash damages and parking subsidies.

The standard suburban arterial experience is long waits at traffic signals, jack-rabbit races to the next signal, followed by more long waits, repeated day after day. A better option is slower, more constant speeds. LaPlante (2008) points out that coordinated signals are easier to integrate into slow-speed networks and suggests that a 30 mph street with coordinated traffic signals can perform as well as a 45 mph street with stop and start movement.

Slower speeds enable more efficient use of existing thoroughfares. Taylor (1997) modeled traffic efficiency measures including travel time and fuel usage, and found that a 37 mph speed limit with coordinated traffic signals performed best, while a 31 mph speed limit with coordinated signals performed nearly as well in most cases. Delay times were least for the 25 mph speed limit.

A good summary of sane and sensible congestion policies is offered by the European Conference of Transport Ministers (2007). The key recommendations are as follows. One, coordinate land use planning with congestion management. Two, deliver predictable travel times. Three, manage high-traffic roadways (with road pricing, parking demand management, and traffic restrictions) to preserve adequate system performance. The study observed,

> Roads in major metropolitan areas are never built to allow free-flow travel at all times of the day, including in particular peak periods… Empty cities are not generally considered successful cities; nor should empty roads.
>
> - *Urban Traffic Congestion, Summary Document (p. 19)*

The University of Minnesota's Asking the Right Questions report (2007) looked into the implications of that. The study found that "even as congestion is getting worse, most people in the Twin Cities are finding it easier to get where they need to go," which was the result of changes in development patterns and housing choices. This suggests that a single-minded focus on congestion may overlook what is important to most people – the ability to quickly and easily get where they want to go.

CONCLUSION

The sustainable network classification proposed in this essay reflects a vision of ideal patterns and principles. It does not attempt to accommodate or compromise with existing practices that do not contribute to more humane and sustainable built environments. This is undeniably liberating, but also may sideline the effort as trivial and excessively idealistic.

The sustainable network classification consists of the following elements:

1) Connectivity and place accessibility are prerequisite conditions for the block, neighborhood and city scale relationships.

2) Block scale relationship: person-capacity per lane to place context. The multimodal, per-lane capacity of thoroughfares is related to walkability design elements. The latter are coordinated on a rural-to-urban spectrum of place contexts. Spatially efficient modes are prioritized, and all thoroughfares in nonindustrial, built-up contexts are pedestrian-oriented places.

3) Neighborhood scale relationship: network accessibility to land use movement sensitivity. The accessibility of thoroughfare segments is related to the requirements of various land uses for adjacent multimodal traffic, in order to create viable neighborhood structure.

4) City scale concept: network interrelationships organized by settlement scale. A framework of settlement scale organizes a nexus of relationships between networks and between network scales.

5) All of the above conditions and relationships must be considered concurrently and coordinated to the maximum degree possible.

This essay is only one step towards a fully elaborated and tested sustainable network classification. It can undoubtedly be improved upon. Networks overlap and interact in complex ways and it is fair to say that no one yet fully understands all the interactions and feedback loops between transportation networks and settlements across all scales. The author's hope is that this essay will begin new dialogs and give added impetus to ongoing discussions. Questions, corrections and discussion are requested and welcome.

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