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Balanced Transport and Sustainable Urbanism: Enhancing Mobility and Accessibility through Institutional, Demand Management, and Land-Use Initiatives

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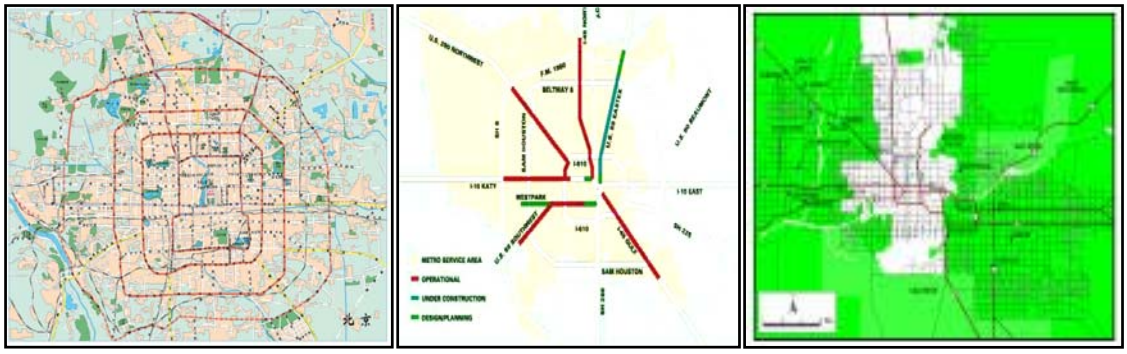
1. Growth in Chinese Cities

Chinese cities and other rapidly urbanizing parts of the developing world face immense challenges as they attempt to balance and jointly pursue economic development and environmental sustainability objectives. Chinese cities like Beijing, Shanghai, and Dalian are experiencing motorization rates of 20% to 25% annually.[1] The sheer scale and rapidity of growth in the population of automobiles is daunting, challenging and at times overwhelming the institutional and administrative capacities of local and national agencies to build sufficient infrastructure and strategically plan for and manage travel demand.

Over the past decade, many Chinese cities have adopted a traditional western approach in responding to mounting problems of traffic congestion, airborne pollutants, rising accident rates, and other ills associated with automobile-oriented societies. This has been one of mainly technological and supply-side solutions, in the form of super-freeways and viaducts, expansive roadway capacity, intelligent transportation systems (ITS), and other technical exigencies that seek to accommodate pressures wrought by rapid motorization. Might this be placing Chinese cities on the same trajectory followed by most American cities and increasing numbers of those in Europe, Canada, and Australasia: rising automobile dependency and the associated problems of galloping sprawl, fossil-fuel resource depletion, high rates of greenhouse gas emissions, and social exclusion by class and ethnicity?

The city of Beijing, for example, is collared by a series of ring roads, most designed as grade-separated, limited-access facilities similar to interstate highways in the United States and motorways and tollways in England and France. Even the Beijing metro is circumferential in design, meant to serve crosstown public-transport trips. If experiences in the United States and England are an accurate barometer, the continual construction of ring roads further and further out along the urban/exurban fringes can be expected over time to encourage increased "scatteration" – i.e., spread-out, low-density, automobile-dependent settlement patterns. In the case of Beijing, further exasperating the situation is the historical development of the central city along the pattern of "superblock grids". As in the case of many international capitals, modern-day Beijing was designed and platted at a scale that symbolically expresses national strength and prosperity. Also behind the superblock arrangement has been the post-1949 government policy of *danwei* wherein work units were assigned the responsibility of providing worker housing. Huge tracts of *danwei* land have left Beijing with long block lengths and few through roads or intermediate collector streets that form a road hierarchy. While grid street patterns work well at a neighborhood scale, when designed at a citywide scale along Le Corbusier's formalist design principles, they too become a force toward increasing dependency upon motorized forms of transport. In terms of the geomorphology of its transportation system, the superimposition of new ring roads with the historical superblock grid surface-street network squarely places Beijing in the ranks of America's two most automobile-dependent cities: Houston, Texas (with 3 ring roads) and Phoenix, Arizona (which features a symmetrical but massive superblock grid network) (Figure 1).



Beijing, China **Houston, Texas** **Phoenix, Arizona**

Figure 1. Beijing, China's Regional Road Infrastructure: A Hybrid of America's Two Most Car-Dependent Cities – Houston and Phoenix?

The combination of a grid surface-street arterial network and a circumferential limited-access freeway network is a potentially powerful elixir for dispersed and disconnected patterns of suburban and exurban growth. Grid-iron street networks serve to evenly diffuse motorized traffic and land development. Fine-grained rectilinear grids, such as in Savannah, Georgia, where land was platted with 30 to 40 meter block faces several centuries ago, promote high connectivity and less circuitous travel for pedestrians, horse-carts, and other non-motorized modes (Figure 2). Superblock grids in a highly motorized setting, on the other hand, can substantially increase vehicle kilometers traveled (VKT). And while ring roads reduce central-city congestion by deflecting through traffic to the periphery, they do so at the expense of increased travel circuity. According to Kenworthy and Laube, in their 2001 book on *Automobile Dependence in Cities*, Houston and Phoenix averaged among the highest rates of vehicle kilometers traveled per capita (VKT/person) in the world in 1990: 13,424 and 13,049, respectively.[2]

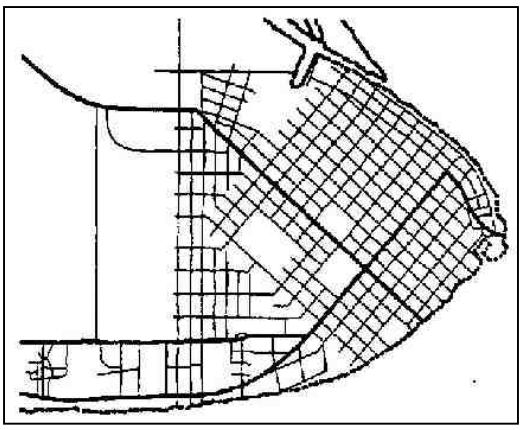


Figure 2. Neighborhood-scale Grid-Iron Street Patterns Provide High Levels of Connectivity for Non-Motorized Transport: Savannah, Georgia

VKT per capita in Chinese cities are thought to be rising at least as rapidly as motorization rates, and quite probably much faster. This is largely because average journey distances are rapidly increasing, in Shanghai at the rate of around 10% annually. Rising jobs-housing imbalances and spatial mismatches, prompted in part by the changeover to a market-based economy that has led to the segregation of land uses, is partly behind increasing journey distances. When working for state enterprises, many Chinese workers lived in state-assisted housing that was situated at or near (or within a bus-transit ride of) the factory worksite. The introduction of differential land rents has witnessed the displacement of many long-time central city residents to outlying areas, sometimes in master-planned new towns (such as the Pudong area east of central Shanghai). Lengthening journeys has in turned encouraged increased motorized travel as journeys become too taxing for foot and bicycle travel: modal-split statistics for Shanghai reveal a conversion of walk trips to bicycle trips and car travel and a switch of former public-transport trips to private automobiles.

Rising motorization and its circular impacts on sprawl are alarming not only in terms of their long-term implications for the natural environment and levels of economic productivity. There should be cause for social concerns as well. One issue is the rising conflicts between motorized and non-motorized transport. Several Chinese cities have witnessed the conversion of dedicated bicycle-lanes to motorized lanes in an effort to expedite the flow of private automobiles and lorries as well as to, presumably, reduce accident rates. Given that far more Chinese own and use bicycles than private cars, this reallocation of an increasingly scarce resource – urban space – to private motorists raises social equity concerns.

It is also important to realize that in rapidly growing settings, experiences have shown time and again that road widenings and supply-side solutions only provide short-term congestion relief; because of behavioral shifts (in mode, routes, and time-of-day) and structural adjustments (including land-use shifts), newly expanded capacity quickly gets consumed – the so-called "induced travel demand" phenomenon.[3] Experiences suggest induced travel demand is prevalent in Chinese cities. In central Beijing, for example, the average travel speed has plummeted from 45 kph (kilometers per hour) in 1994 to 12 kph in 2003. Operating speeds are just 7 kph on several major arteries of the city and peak period today stretches over 11 hours. During peak times, one-fifth of Beijing's roads and intersections come to a standstill, with traffic speeds less than 5 kph.[4] Buses in mixed traffic conditions are especially vulnerable to stop-and-go traffic – as large, lumbering, less maneuverable vehicles that must weave in and out of lanes to pick up and discharge customers, regular-service buses suffer the most when traffic conditions deteriorate.[5] The average speeds of buses in major Chinese cities have fallen from 20 to 25 kph in the 1970s to the 10-15 kph range today. Presently, the average bus speed is estimated to be 9 kph in Beijing and 10 kph in Shanghai.[6]

The continued supply-side focus in responding to traffic woes – not only expanding road systems but also major investments in metro undergrounds, light rail transit, bus rapid transit, and even Maglev systems -- is reflected in official planning documents. In late-2003, the City of Beijing drafted the "Beijing Transportation Development Framework"

and a year earlier the City of Shanghai prepared the "Shanghai Metropolitan Transport White Paper". Both plans focus on capacity expansions and modernization of infrastructure as the instruments for relieving traffic congestion and spurring economic productivity. They are noticeably silent in their treatment of transport-land use integration and generally skirt topics such as sustainability, livability, and accessibility. The need for a more balanced, holistic approach to long-range transport planning and development has not gone unnoticed. In a World Bank symposium on "China's Urban Transport Development Strategy", in his keynote address, a senior Chinese official observed: "The key problem of urban transport in China is the lack of a comprehensive transport development strategy, lack of a coherent transport policy, and disorder in transport management. All these contribute to growing traffic jams, declining vehicle speeds, and low efficiency – a typical case of downward spiral and vicious cycle."[7]

The supply-side leanings of urban transport plans and investments are rooted in national economic development principles. An overriding cultural ideology that gets expressed in Chinese transport investments is "Xian Sheng Chan, Hou Sheng Huo" – "first production, then life".[8] That is, priority goes to building roads for the assemblage of raw materials and distribution of finished products. The mobility needs of urban dwellers is secondary; in the midst of rapidly increasing household incomes, however, motorists experience the residual benefits of designing road infrastructure to facilitate freight and goods movements. Supply-side responses also stand to reason in cities like Beijing where 10 percent annual increases in motorization continue to outstrip the 2 percent annual increase in roadway capacity. Balanced transport programs do not ignore the need for road expansion and new construction; rather a diversity of transport initiatives are pursued that promote a wider array of objectives than simply enhanced mobility.

It should be noted that the seemingly preoccupation with supply-side strategies is not limited to Chinese cities. Similar comments could be made for Jakarta, Manila, Bangkok, and other rapidly growing and modernizing mega-cities of Asia. Given the sheer size and dominance of Chinese cities, consideration should be given to making them exemplars and paragons of sustainable transport and urbanism from which other parts of the developing world –particularly Asia -- could learn and emulate. It also needs to be re-emphasized that there are perfectly good reasons for China's substantial investment in motorways and elevated freeways. In all Chinese cities, urban transport infrastructure was initially designed for largely non-motorized travel. Not only do Chinese cities devote comparatively small amounts of land area to road space (historically less than 10%) than most other global cities, the limited amount of distributor roads and collectors that tie into mainline facilities has also witnessed a poor functional hierarchy. Sustainable, balanced transport planning and development is not "anti-highway" or "anti-car": rather multi-modal, holistic strategies are called for that recognize the inherent efficiencies and resourcefulness of different transport modes for different purposes, demand-rationing principles, and transport/land-use integration.

2. Pursuing a Transport Policy Model that Embraces Mobility and Land-Use Management

As we embark upon a new millennium, a more balanced approach to transportation system planning and management might be considered for urban China. This approach balances both demand- and supply-side transport initiatives, elevates "accessibility-based" planning to the same level and stature of "mobility-based" planning, and introduces institutional, administrative, and management techniques, including road pricing, that place Chinese cities on a sustainable pathway – economically, environmentally, and socially. Principles of "sustainability" and "livability" should also be rooted in strategic long-range transport and land-use planning, operationalized through performance indicators that track over time progress made in conserving resources, promoting safety, and enhancing quality-of-living in investing and deploying transport resources.

This paper focuses on three core areas that mega-cities of the developing world, including those in China, should seriously consider: "transit-first" policies that actively promote public transport as the most resourceful and sustainable form of motorized transport; land-use initiatives that elevate accessibility principles and promote compact, mixed-use, and pedestrian-friendly patterns of urbanism; and demand-management programs that redistribute travel not only by mode and space but also by time. International examples and mini-case studies are used to underscore the importance of matching mobility objectives with accessibility, sustainability, and livability principles as well as when pursuing a balance of supply-side and demand-side strategies.

3. Transit First Initiatives

Many Chinese cities have made impressive progress on the public transit front to date, such as the conversion of diesel-fuel vehicles to clean-fuel propulsion – e.g., compressed natural gas (CNG) buses found in cities like Beijing and Xi'an. Dedicated lanes are also commonly provided for buses and new rail links (most recently highlighted by Shanghai's first-of-a-kind magnetic-levitation train to the Pudong International Airport) are continually being built. Also, bus fares are generally kept at affordable levels (sometimes causing oversubscription problems during peak periods) and the privatization of many bus operations has served to hold a lid on operating costs.

Notwithstanding such headway, public transport is still viewed as a fairly low transport priority in many Chinese cities. Sometimes investment in bus transport constitutes only around 5% of that in road investments. A "transit first" policy would substantially change this pro-ration. In this regard, Chinese cities might borrow a chapter from other parts of the world that are actively pursuing "transit first" strategies. Two examples are presented in this section: Zürich, Switzerland and Bogotá, Colombia. Both cases show that transit-first policies are a hallmark of sustainable transport and urbanism.

3.1 *Zürich: Priority Allocation of Space and Time "Resources" to Trams and Buses*

Zürich represents a case *par excellence* where scarce resources – specifically, road space and traffic-signal time – have been substantially reassigned to buses, trams, and other forms of public transport. A combination of technological advancements (e.g., real-time dynamic signalization systems oriented to maximizing passenger throughputs on buses and trams) and system management (e.g.., converting motorway lanes to dedicated busways) have been the cornerstones of Zürich's transit-first initiatives.

Faced with the prospect of building German-style U-Bahn (underground) train services in the 1970s, Zürich residents expressed fear that rapid-speed trains would unleash decentralization and alter the historical human-scale fabric of the core city. A conscientious decision was made to promote surface transit improvements through demand rationing. This mainly meant dedicating substantial amounts of road rights-of-way to trams, buses, and bicycles.[9] Space reallocations were matched by temporal reallocations – namely, the allotment of green traffic signal times in favor of high-capacity carriers (i.e., trams and buses). Advanced monitoring and information technologies and dynamic, real-time traffic signalization systems have been used to give preferences to trams and buses at virtually all signalized intersections as well as to provide a continuous flow of information to customers about when transit vehicles are expected to arrive. Zürich's traffic system functions like a citywide ramp-metering program. The city has been divided into sectors, each consisting of three to twelve sets of traffic signals. Through real-time monitoring, traffic signals in each sector are adjusted to keep traffic volumes and queues evenly spread throughout the city. If a sector near the core is congested in the morning, green time in outlying sectors will be shortened to reduce the discharge rate of inflowing traffic. Since the full introduction of the system in the mid-1980s, waiting times for trams and buses at signalized intersctions during the evening rush hour have fallen by around 40 percent.[10]

Minimum-delay, surface-street transit connections have won over most Zürich residents to public transit, producing one of the highest per capita ridership levels in the world. Zürich is also one of the world's wealthiest cities on a per capita basis. Limited parking supplies and hefty parking fees have prompted many middle-income households to give up car ownership altogether, relying on a combination of transit, walking, cycling, and carsharing to meet their mobility needs. Zürich's experiences show that compactness, prosperity, and ecological transportation go hand in hand quite nicely.

3.2 *Bogotá: Bus Rapid Transit*

Bogotá, the Andean capital of Colombia, has gained global recognition for its highly efficient and productive bus rapid transit (BRT) system, called Transmilineo.[11] For a city of 7 million inhabitants facing civil conflict and deep economic problems, Bogotá's emergence as one of the world's most sustainable metropolises is all the more remarkable.

In the late 1990s, Bogotá began operating a high-speed, high-capacity bus system, called

Transmilenio, building upon Curitiba, Brazil's much-celebrated successes with dedicated busways. A big difference, however, is that Curitiba relies principally upon circular, cross-town bus routes to interconnect radial busways. Outside of downtown, relatively little was invested in pedestrian and bikeway improvements. Bogotá, on the other hand, actively embraced pedestrian and bicycle access.

The 42-kilometer, 3-line Transmilenio busway is the centerpiece of Bogotá's vast bus network. (The dedicated system will eventually expand to 22 lines covering 391 kilometers.) Bus lanes are situated in boulevard medians, with weather protected, attractively designed stations spaced every 500 meters or so. Because of dual carriageways that enable buses to overtake each other and high-level platforms that allow expeditious boardings and alightings, Transmilenio has a throughput of some 35,000 persons per direction per hour, a number than matches that of many metro-rail system. Some 850,000 passengers ride Transmilenio buses each weekday, three times the ridership of two rail lines in Medellin, Colombia (achieved at less than one-fifth of the Medellin Metro's construction costs) and providing for a social rate of return of 61 percent.[12]

Particularly important to the transitway has been Bogotá's attention to pedestrian and bicycle access, in the form of "green connectors". Perpendicular and grade-separated pedways and bikeways connect some of the poorest barrios and informal housing settlements (with highly transit-dependent populations) to the busways. Other innovative features of Bogotá's sustainable transport program include license-plate rationing, parking management, and car-free districting. Bogotá is an extraordinary example of matching infrastructure "hardware" with public-policy "software": Latin's America's most extensive network of cycleways (250 km), the world longest pedestrian corridor (17 km), and the planet's biggest Car Free Day (covering an entire city of 35,000 hectares). Today, 43 percent of the city's transport investment budget goes to ancillary policy measures.

Transmilenio's numbers are impressive. Average bus speeds increased from 12 kph to 27 kph along the two busiest busway corridors. This led to a 32 percent reduction in average trip times for users of the system.[13] Accidents have fallen some 93 percent and and air pollution has improved: from 1999 when Transmilenio opened to 2001, injuries and collisions along bus-served corridors fell by 75 to 80 percent and sulfur dioxide, nitrogen oxides, and particulate matter had dropped 43, 18, and 12 percent respectively.[14] During its first year, Transmilenio had a 98 percent passenger approval rating. Eleven percent of Transmilenio riders are former car drivers.

While Bogotá's Transmilenio system has not dramatically altered the cityscape to date, at least when compared to cities like Curitiba, Brazil (as discussed later), recent research shows that commercial properties have reaped benefits from proximity to busway stations. Figure 3 shows properties that were surveyed by Targa and Rodriquez in a study of Transmilenio's land-rent capitalization impacts. Using hedonic price models, the authors measured a monthly rental discount of 1.87 percent for every additional 0.1 km from a BRT station, all else being equal.[15] This suggests a pent-up market demand

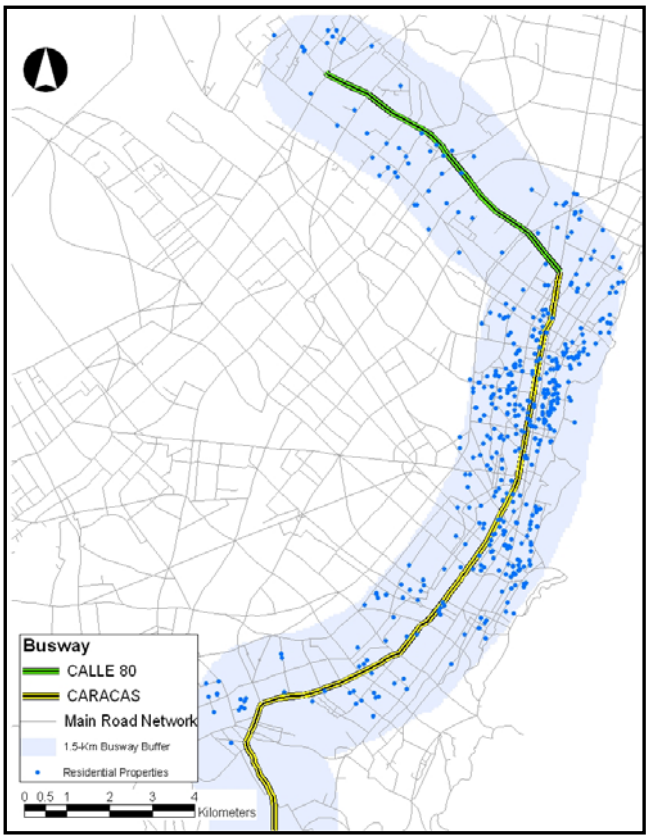


Figure 3. Commercial Properties Studied in Relation to Bogotá's TransMilenio System, 2002. *Source*: F. Targa and D. Rodriquez: Analysis of Bogotá's Bus Rapid Transit System and its Impact on Land Development", *Carolina Planning Journal*, Winter 2003-2004.

for the accessibility benefits conferred by high-quality bus-based transit in cities of developing countries.

As with many successful transit investments, it has been the attention to design details, matched by good macro-scale planning, that has contributed to Tranmilenio's success. Car parking is mainly limited to the end stations of the Transmilenio busway. Nearly half of the 57 intermediate stations are served by skywalks/pedestrian overpasses. A phalanx of sidewalks and bikeways feed into all stations, most embellished by vegetative landscaping. Some two dozen civic plazas, pocket parks, and recreational facilities lie within a half kilometer of busway stops. Today, 45 percent of Transmilenio users reach stations by foot or bicycle.

Bicycle facilities extend well beyond Transmilenio stations. Currently, Bogotá boasts over 200 kilometers of dedicated bicycle paths and lanes. The Dutch-advised long-range plan calls for the figure to almost double over the next 30 years. The $178 million spent to date for bicycle improvements is about half the total amount the entire United States spends annually on cycling infrastructure. Over the past decade since bikeways have been introduced, the share of daily trips by cycling has grown from 0.9 percent to 4

percent. A hospitable environment has helped. Perched in a flat valley high in the Andes, Bogotá enjoys a mild climate. So have high densities (at 12,000 persons per square kilometer, Bogotá is one of the densest cities in the Western Hemisphere) and mixed land-use patterns. As a result, 77 percent of daily trips in the city are less than 10 kilometers. Bicycles can often cover 10 kilometers faster than cars because many of the city's traffic-snarled roads.

To further promote cycling, Bogotá officials have held car-free days on the first Thursday of February since 2000. On Sundays, the city closes 120 kilometers of main roads for 7 hours to create a "Ciclovia" ("Cycling Way") for cyclists, skaters, and pedestrians. When weather's good, as many as a million and a half cyclists hit the streets of Bogotá on Sundays. Bike-friendly initiatives have been matched by car-restricted ones. Through a tag system (Pico y Paca), 40 percent of cars have to be off of central-city streets during peak hours every day. Bollards have been installed throughout the core to prevent motorists from parking on sidewalks and bikeways.

How can a city in a developing country saddled with guerilla warfare and armed conflict, one might ask, justify investing scarce public resources in "amenities" like pedways and bikepaths? Aren't education, health care, sanitation, housing, and other pressing urban concerns of much higher priority? Bogotá's channeling of funds into the transport sector reflects, in part, the visions of several liberal mayors who have openly embraced smart-growth planning under the premise that a functional, world-class city can halt a brain drain and, over the long run, entice foreign capital and investment. The poor, they believe, will eventually benefit from better jobs and living conditions. Former mayor and now international planning consultant, Enrique Peñalosa, views the city's investments as social equalizers. He writes:

> A premise of the new city is that we want society to be as egalitarian as possible. For this purpose, quality of life distribution is more important than income distribution. The equality that really matters is that relevant to a child: access to adequate nutrition, recreation, education, sports facilities, green spaces and a living environment as free of motor vehicles as possible. The city should have abundant cultural offers; public spaces with people; low levels of noise and air pollution; and short travel times.[16]

Some progress has been made in creating Bogota-like BRT services in Chinese cities. In 1997, Beijing opened an exclusive bus lane on Changan Street. Before the opening, the average bus speed was 16 kph. After the opening, the average speed increased to 20 kph and on-time arrival rates increased 43.6%. More exclusive bus-lanes have since been added. In Shenshen, a "green channel" of public transport corridors has been developed. While important steps, less consideration has been given to the integration of BRT and land development than in Latin American cities.

3.3 *Investment Considerations*

Experiences in Zürich and Bogota underscore the potential mobility benefits of allocating

resources (space, time, and funding) to promote efficient forms of mobility – public transport. Ideally, transit-first policies should reinforce and promote desired long-range land-use objectives. This is very much the Scandinavian model, such as in the case of the celebrated "Finger Plan" of Copenhagen, Denmark and the "Planetary Cluster Plan" of Stockholm, Sweden. In both of these instances, corridors for channeling overspill growth from the urban centers were defined early in the planning process, and rail infrastructure was built, often in advance of demand, to steer growth along desired growth axes. As importantly, greenbelt wedges set aside as agricultural preserves, open space, and natural habitats were also designated and accordingly major infrastructure was directed away from these districts. The evolution of Copenhagen from a Finger Plan, to a directed rail-investment program along defined growth axes, to finger-like urbanization patterns is revealed by Figure 4.

Figure 4. Copenhagen's "Transit First" Spatial Evolution: From Finger Plan, to Five-Axis Radial Investment, to Corridors of Satellite, Rail-Served New Towns

Monocentric (strong-centered) patterns of development ensure the metropolitan core remains dominant in employment and retail activities, however as regions grow beyond the 3 million population mark, this can be at the expense of increased congestion from travel convergence and agglomeration diseconomies plus rising VKT per capita. For this reason, Toronto, Canada has invested in radial rail systems and sited development to transform its transport-land use arrangement from a monocentric, full-radial form to a multi-centric, sub-radial configuration (Figure 5). This has helped to rationalize travelsheds, shortening average travel distances and promoting public transport usage (in part because more trips are over intermediate distances of 4 to 8 kilometers, the distances for which public transport is most competitive with the private automobile). Today, two of Toronto's more notable second-tier centers – North York and Scarborough – capture over 25 percent of journeys-to-work by public transport, a phenomenally high market share for non-central-business-district locations by North American standards.[17] The Toronto region appears to be one of the few where journey distances seem to be

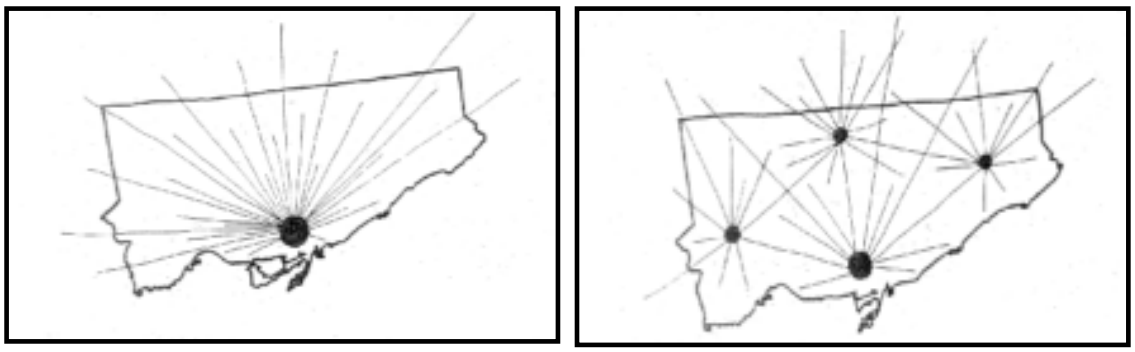


Figure 5. From a Monocentric-Full Radial Form to a Multi-Centric, Sub-Radial Form: Rail-Land Use Evolution in Toronto, Canada

declining; according to Kenworthy and Laube's international sourcebook data, the mean trip length fell in the Greater Toronto Area from 9.9 kilometers in 1981 to 6.3 kilometers in 1991.[18]

While not exactly "transit first" initiatives, Chinese largest cities are funneling substantial resources into public transport. Both Shanghai and Beijing are turning to high-capacity, high-performance rail-based transit as critical links in long-range regional transport plans. The 2000 *Comprehensive Plan of Shanghai*, for instance, calls for 4 high-speed railways, 8 underground metro lines, and 5 light-rail lines, totally some 780 km in length, to be built by 2020. Also, one to two commuter railway lines are planned that will connect outlying new towns and residential communities to the central city. Beijing is also investing heavily in new urban rail systems in preparation for the 2008 Summer Olympic Games. Some 300 km of rail transport is to be in place four years from now. Left to their own devices, experiences generally show that rapid rail transit can be a powerful force to decentralization, especially in rapidly growing settings. This has certainly been the case with the Shinkansen bullet trains of metropolitan Tokyo and Osaka, the Bay Area Rapid Transit (BART) network of San Francisco, or commuter railways of Paris.

4. Land Use Initiatives

All Chinese cities have a strong tradition of strategic and comprehensive land-use planning. More and more master-planned new towns are being built on the peripheries of China's largest cities, some designed along British Mark-II new town principles of "quasi" self-contained, internally balanced communities. However, due to rising land-market pressures and real-estate price differentials, problems of spatial mismatch and jobs-housing-services imbalances are becoming more and more acute in Chinese cities.

Three land-use planning strategies offer promise for reducing VKT per capita through promoting alternatives to private car travel and shortening travel distances: transit

oriented development (TOD), New Urbanism designs, and jobs-housing balance. These are discussed in this section with regards to their potential applicability to Chinese cities.

Land-use initiatives, it should be pointed out, are centrally about enhancing "accessibility". By accessibility is meant a focus on increasing *opportunities* for reaching places and destinations where people and freight often go. Accessibility, as a guiding principle, shifts the focus from planning for movement *per se* to planning for activities and social interaction. A fundamental principle of travel is that it is "derived" – we do not travel for travel's sake, but rather for purposes of reaching desired destinations to derive satisfactions and benefits – whether to earn a living, socialize with friends, purchase goods and necessities, or enjoy nature. All things being equal, we prefer to minimize time spent getting somewhere so that we can spend more quality time at our destinations. In this sense, movement, or mobility (i.e., the speed and ease of traversing physical space) is secondary to the primary objectives of spending quality and productive time at destinations. Increased accessibility can promote this by bringing urban activities closer together, such as through commingling and inter-mixing land uses. A blend of mobility-based planning that increases travel speeds and performance and accessibility-based planning that makes co-dependent land uses more proximate to each other is the best platform from which to promote sustainability broadly defined – economic sustainability (e.g., increased productivity), environmental sustainability (e.g., resource conservation), and social sustainability (e.g., human interaction and social justice).

Qing Shen argues that it is an opportune time to strengthen the transport/land-use connection in Chinese cities for three reasons.[19] One, the pace of urban expansion and redevelopment is extremely fast. Rapid changes in land-use can have rapid impacts on travel demand, including mode choice and travel distances. Second, urban transportation access is far from ubiquitous. Accessibility levels vary markedly within Chinese cities. When and where transport infrastructure is targeted can strongly shape urban form. Lastly, government is the sole owner of urban land, providing a streamlined institutional environment for effectively coordinating transport and land development patterns.

4.1 *Transit Oriented Development*

A good model of TOD is Singapore, underscored by the island-state's Constellation Plan and development of compact, mixed-use new towns around many suburban MRT stations. In the United States, the Washington, D.C. area (and particularly, Arlington County, Virginia) has aggressively pursued TOD along the model of public-private partnerships, leading to jointly developed public transit and private office-commercial developments at stations. The ridership and financial pay-offs of these arrangements have been impressive. Similarly, greater Tokyo witnessed the formation of TODs around many suburban and exurban stations through franchising both rail construction and new-town developments to railway consortia that are involved in ancillary real-estate activities, effectively practicing value capture.

Singapore. The city-state of Singapore is internationally renowned for its successful integration of transit and regional development, placing the urbanized island of 2.8

million inhabitants on a sustainable pathway, both economically and environmentally. As part of a national economic development strategy, Singapore has embraced Scandinavian planning principles that call for radial corridors that interconnect the central core with master-planned new towns. Its structure plan, called the Constellation Plan (Figure 6), reflects its namesake – from plan view, it has the appearance of a constellation of satellite "planets", or new towns, that orbit the central core, interspersed by protective greenbelts and interlaced by high-capacity, high-performance rail transit. Like Stockholm and Copenhagen, this rail-served settlement pattern has produced tremendous transportation benefits: low VKT per capita (lower than any urbanized region worldwide with per capita GDRP over US$10,000) and high transit modal splits (480 annual transit trips per capita in 2002).

Singapore adopted the approach of building new towns that are not independent, self-contained units but rather nodes with specialized functions that interact with and depend upon other new towns. Some satellite centers are primarily industrial estates, some are predominantly dormitory communities, and most are mixed-use enclaves. Around three-quarters of residents of master-planned new towns work outside of their area of residence. Most, however, commute within the radial corridor that connects their new town to Singapore's Central Business District. This means travel is predominantly within, not between, rail-served corridors. Also, the dispersal of mixed land uses along corridors has created two-way travel flows and spread travel demand more evenly throughout the day.

Singapore is also noted for its progressive "transit first" policies that complement its transit-oriented Constellation Plan. The city has introduced a three-tier fiscal program that comes as close to "getting the prices right" within the urban transport sector as any city in the world. The first tier of charges is subscription fees for owning a car. Comprised of high registration fees, import duties for automobile purchases, and a licensing surcharge based on a quota system (indexed to congestion levels), these charges principally cover fixed costs associated with providing basic levels of road infrastructure and parking facilities. The second tier of charges are use-related, in the form of fuel taxes and parking fees, that cover incremental costs for scaling road capacity to traffic volumes and maintaining roadway infrastructure. The third set of charges – in the form of real-time electronic road pricing (ERP) – force motorists to internalize the externalities they impose in using their cars during peak hours. Fees fluctuate according to congestion levels, meaning motorists bear some of the costs they impose on others such as time delays and air pollution. Within a month of initiating electronic road pricing, traffic along a main thoroughfare fell by 15 percent and average rush-hours speeds rose from 36 to 58 kph. Vehicle quotas, congestion prices, and an assortment of fees and surtaxes (that add as much as 150 percent to a car's open market value) have reduced Singapore's annual vehicle population growth from 6 percent fifteen years ago to under 3 percent today, a remarkable achievement for a city where per capita incomes have risen faster over the past two decades than virtually anywhere in the world.

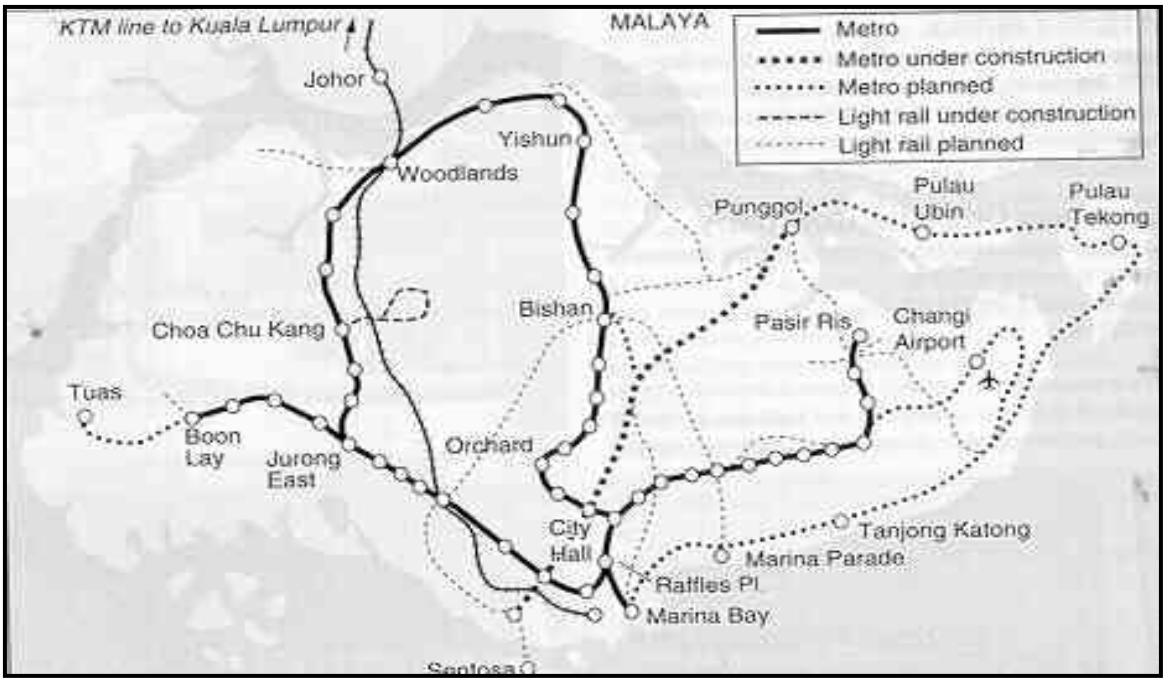


Figure 6. Singapore's Constellation Plan

Arlington County. Virginia. Compact mixed-use nodes around rail stations in a land-constrained city-state like Singapore is understandable, however TOD is even gaining a foothold in car-friendly America. No place in the United States has witnessed more high-rise, mixed-use development along a rail corridor over the past three decades than Arlington County, Virginia. Arlington County, Virginia is a textbook example of creating a vision (the "bull's eye" concept plan, shown in Figure 7) and putting in place appropriate implementation tools to achieve the vision. Through a collaborative effort that engaged local stakeholders and an ambitious campaign that targeted supportive infrastructure improvements to rail stops along the corridor, Arlington County managed to transform the Metrorail Orange line into a showcase of transit-supportive development, with mid-to-high rise towers and multiple uses today flanking the Rosslyn, Courthouse, Clarendon, Virginia Square, and Ballston Metrorail stations. With the bull's eye methaphor in place to guide on-going planning (borrowing from the experiences of great "transit metropolises" like Copenhagen and Stockholm), Arlington County proceeded to leverage Metrorail's presence and transform once dormant neighborhoods into vibrant clusters of office, retail, and residential development.

In a recent national study, I probed the potential ridership benefits of TOD even in a car-dependent country like the United States. Arlington County's two major rail corridors – Rosslyn-Ballston and Jefferson Davis (see Figure 8) – have experienced a tremendous increase in building activity since Metrorail's 1978 opening: 24.4 million square feet of

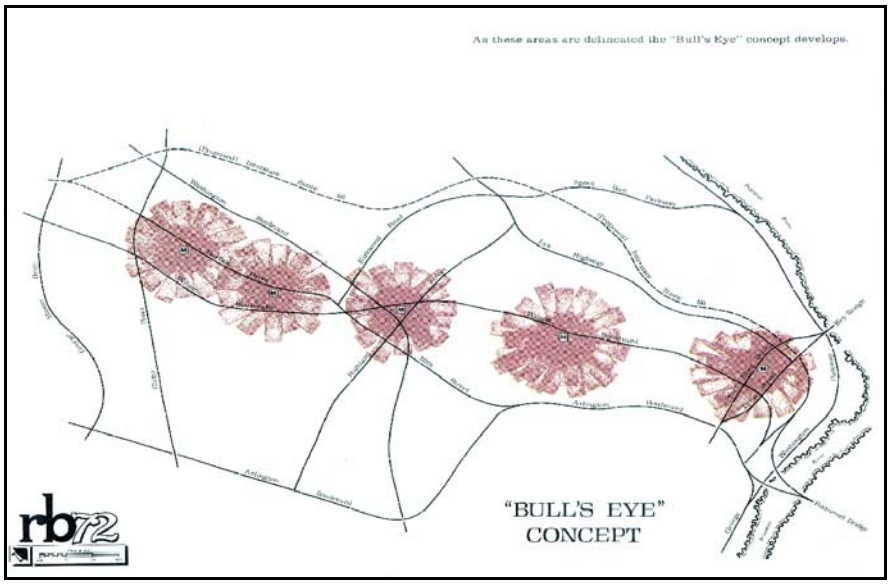


Figure 7. Arlington County, Virginia's "Bull's Eye" Vision for the Rosslyn-Ballston Corridor. *Source:* Arlington County Department of Community Planning, Housing and Development.

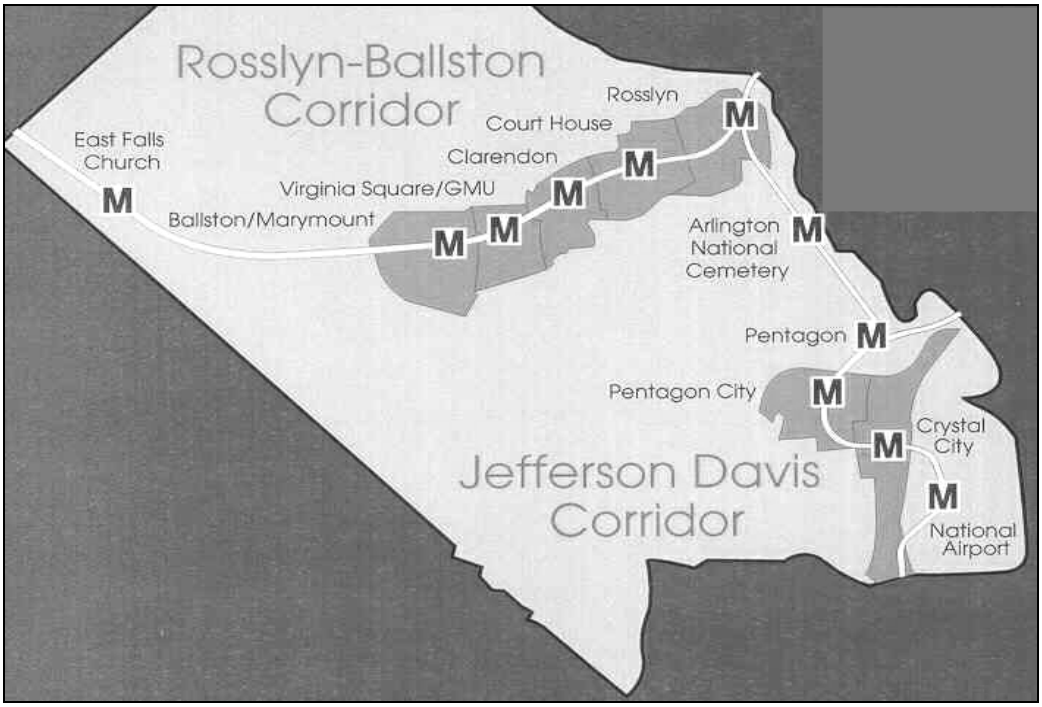


Figure 8. Washington Metrorail Rail Stations in Arlington County. The station areas of the seven Metrorail stations with significant development activity since 1970 are shaded.

office space, 3.8 million square feet of retail space, some 24,000 mixed-income dwelling units, and over 6300 hotel rooms.[20] Of the nearly 190,000 people today living in Arlington County, 26 percent reside in Metrorail corridors even though these corridors (as represented by darker areas in Figure 8) comprise only 8 percent of county land area. If the development added to these two corridors had been built at suburban density standards, such as in neighboring Fairfax County, Virginia, seven times as much land area would have been required.

The addition of 35+ million square feet of new development along two rail-served radial axes was hardly the result of good fortune or happenstance. The transformation of once-rural Arlington County into a showcase of compact, mixed-use TOD has been the product of ambitious, laser-focused station-area planning and investment. Prior to Metrorail's arrival, Arlington County planners understood that high-performance transit provided an unprecedented opportunity to shape future growth and proceeded to introduce various strategies — targeted infrastructure improvements, incentive zoning, development proffers, permissive and as-of-right zoning — to entice private investments around stations. After preparing countywide and station-area plans on desired land-use outcomes, density and setback configurations, and circulation systems, zoning classifications were changed and developments that complied with these classifications could proceed unencumbered. The ability of complying developers to create TODs "as-of-right" was particularly important for it meant developers could line up capital, secure loans, incur upfront costs, and phase-in construction without the fear of local government "changing its mind."

The pay-off of concentrated growth along rail corridors is revealed in Arlington County's transit ridership statistics. The County today boasts one of the highest percentages of transit usage in the Washington, D.C. region, with 39.3 percent of Metrorail corridor residents commuting to work by public transit.[21] This is twice the share of County residents who live outside of Metrorail corridors. Self-selection is evident in that around two-thirds of employed-residents in several apartments and condominium projects near Rosslyn and Ballston stations take transit to work.[22] An important outcome of promoting mixed-use development along rail corridors has been balanced jobs and housing growth which in turn has produced balanced two-way travel flows. Figure 9 shows that counts of station entries and exits in Arlington County were nearly equal during peak hours as well as the off-peak. During the morning rush hours, many of the county's Metrorail stations are both trip origins and destinations, meaning trains and buses are full in both directions. The presence of so much retail-entertainment-hotel activities along the County's metrorail corridors has further filled trains and buses during the midday and on weekends. Arlington County averages higher shares of transit boardings and alightings at its stations in off-peak hours than other jurisdiction in the region with the exception of downtown Washington, D.C. Balanced, mixed-use development has translated into as close to 24/7 ridership profile as any U.S. setting outside of a CBD.

In probing the ridership "bonus" of TOD, I examined yearly data on building activities and station entries/exits for Arlington County station areas over the 1985 to 2002 period. Using multiple regression equations that simultaneously estimated ridership,

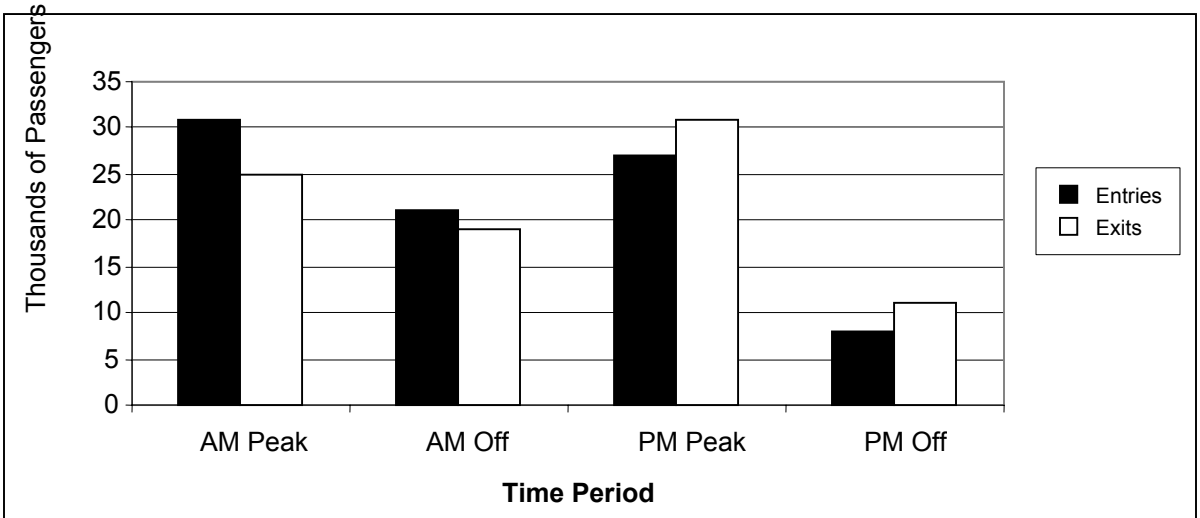


Figure 9. Arlington County Metrorail Stations Entries and Exits by Time Period. *Source:* Arlington County Department of Community Planning, Housing and Development

development, and service levels as joint functions of each other, the analysis revealed the following. Ridership has been most responsive to increases in office and retail development. Every 100,000 square feet of added office and retail floorspace increased average daily boardings by 50. Residential development increased ridership in part by prompting increases in service frequency. In combination, the two factors – new housing and more frequent headways – boosted patronage: every 100 additional residential units, when combined with 100 additional rail-car passenger spaces per day, led to more than 50 additional boardings per day.

Tokyo, Japan. Global experiences reveal that TOD is not necessarily the exclusive province of the public sector. In most market economies, the private sector largely dictates land development, and when given the opportunity can be inclined to also finance and integrate supportive infrastructure, including fixed-guideway rail transit. In many automobile-dependent societies, most notably the United States, there has often been a disconnect between privately-led land development and publicly provided infrastructure. Experiences in Tokyo and Osaka show privatization of suburban railway development can spur compact, mixed-use patterns of suburbanization. In Japan, suburban railway companies are mainly in the real estate business. All were granted exclusive franchises to co-develop suburban railways and master-planned new towns, serving to off-load funding responsibilities from the public sector and, in light of corporate profit motives, ensuring high degrees of efficiency and transit/land-use integration. Most private railway companies that have invested in suburban railways surrounding Tokyo and Osaka are huge conglomerates that pursue other commercial ventures, such as the construction and operation of hotels, department stores, sport stadia, and other ancillary businesses. Transportation is a loss-leader in that huge profits (on average 50% to 70% returns on investment over the 1980 to 1993 period) are derived from land sales near railway stations.[23] Companies make handsome profits through value

capture, and society at-large benefits from the close nexus between rail and land-use development.

While China's system of government ownership of land and setting of rents might dilute private interest in the joint development of railways and ancillary real-estate, strategies like long-term (e.g., 100 year) lease arrangements and public-private partnerships (as through franchising as in the case of Japan) might very well attract corporate interest in building and bundling railways and new town settlements. This would be especially the case as road congestion worsens and businesses, industry, and households place a higher premium on being in highly accessible, transit-served locations.

4.2 *New Urbanism and Traditional Design Principles*

Traditional neighborhood designs have gained popularity in much of United States and increasingly in Europe and other advanced economies under the banner of New Urbanism. The idea is to return modern suburban designs to an earlier era when smaller units on smaller plots, mixed land uses, internal pathways, and semi-grid street patterns encouraged neighbors to socialize and take care of many activities by foot. Though sometimes criticized for high-mindedness and physical determinism at-the-extreme, from a resource-efficiency standpoint, traditional neighborhood designs receive high marks. U.S. studies show that traditional neighborhoods de-generate and shorten motorized trips, thus reducing vehicle-kilometers-traveled.[24] New Urbanism communities, whether in the form of neo-traditional developments, transit villages, or urban infill, embody the "3 Ds" of sustainable development – density, diversity, and design.[25]

Research suggests household travel consumption falls anywhere between 30 percent and 60 percent in the United States as residential densities double, with the largest declines occurring in areas with high gasoline prices and other restraints on automobile ownership and usage. Besides higher densities, diversity in land uses is also a defining characteristic of most New Urbanism communities. Among Americans who live within a walkable or bikable distance to work, research shows having in-neighborhood grocery stores and shops increases the odds of commuting by non-motorized transport by 17 percentage points.[26] Being able to conveniently pick-up items en route to home in the evening makes alternative means of commuting eminently more attractive.

Whether travel reduction is a primary aim or not of New Urbanism, all sides agree that the private car can be expected to take on a less dominant role in places that promote social interaction, active living, and increased foot and bicycle travel for short-to-moderate distance discretionary trips. While most traditional Chinese cities feature such urban designs, increasing numbers of suburban, exurban, and new town communities on the outskirts of Shanghai, Beijing, Dalian, and other big cities do not. The application of traditional design approaches and creation of a human-scale urban fabric to new towns deserve serious attention as Chinese cities continue to decentralized.

4.3 *Jobs-Housing-Services Balance*

At a corridor and sub-regional scale, jobs-housing balance offers significant opportunities to shorten average journey lengths, rationalize commuting patterns and travelsheds, and inject efficiencies into travel patterns, such as higher rates of bi-directional trip flows. Experiences generally show that land markets, left to their own accord, do not always promote balance through natural "co-location" (e.g., employers trying to locate near labor markets) and often need overt public actions to steer growth.

As longstanding central-city neighborhoods are replaced by modern skyscrapers and mega-scale commercial complexes, more and more Chinese households are being relocated in outlying settings, including master-planned new-towns and semi-rural para-peripheral settlements. Changing land rents structures are also displacing many modest-income households from central cities to the outskirts. Presently, the price for housing in the heart of Beijing goes for as much as 10,000 yuan (US$1,210) per square meter; at such prices, the centrifugal movement of residences to the metropolitan periphery is unavoidable. The emergence of a spatial mismatch in where Chinese urbanites live and where they work is reflected in journey-to-work statistics. In 2003, more than 40 percent of Beijing commuters spent more than an hour to get to work. Only 5.5 percent of workers took less than 20 minutes to reach their job sites. Increased commute time is thought to be predominantly a product of lengthening journeys and worsening congestion as opposed to public transport usage since transit's modal split has fallen over the past decade in virtually all Chinese cities.[27]

The ability of inter-mixing land uses along linear corridors to produce an inter-mixing of bi-directional flows is an under-appreciated benefit of sub-regional land-use balancing. Experiences from Scandinavian cities as well as Curitiba, Brazil underscore this point.

There is no better example of the efficiency and sustainability gains that come from balanced growth than Stockholm, Sweden. The last half-century of strategic regional planning has given rise to a regional settlement and commutation pattern that has substantially lowered car-dependency in middle-income suburbs. Stockholm planners have created jobs-housing balance along rail-served axial corridors. This in turn has produced directional-flow balances. During peak hours, 55 percent of commuters are typically traveling in one direction on trains and 45 percent are heading in the other direction. Stockholm's transit modal share is nearly twice that found in bigger rail-served European cities like Berlin and even higher than inner London's market share. Perhaps most impressive, Stockholm is one of the few places where automobility appears to be receding. Between 1980 and 1990, it was the only city in a sample of 37 global cities that registered a per capita decline in car use -- a drop off of 229 annual kilometers of travel per person.[28]

The broader societal benefits of balancing growth along linear axes and aggressively pursuing a "transit first" policy is underscored by experiences in Curitiba, Brazil. Curitiba, widely viewed as one of the world's most sustainable, well-managed metropolises, is also one of the most accessible -- a product of some forty years of

carefully integrating urbanization and transportation improvements. By emphasizing planning for people rather than cars, Curitiba has evolved along well-defined radial axes that are intensively served by dedicated busways. Along some corridors, elephant-trains of double-articulated buses haul 16,000 passengers per hour, comparable to what much pricier metro-rail systems carry. A design element used to enhance accessibility is the "trinary" -- three parallel roadways with compatible land uses. An important benefit of mixed land uses and transit service levels along these corridors, besides phenomenally high ridership rates, has been balanced, bi-directional flows, ensuring efficient use of available bus capacity, just as in the case of Stockholm. On a per capita basis, Curitiba is one of Brazil's wealthiest city yet it averages considerably more transit trips than much-bigger Rio and São Paulo. It also boasts the cleanest air among any Brazilian city over 1 million inhabitants, despite being a provincial capital with a sizable industrial sector. The strong, workable nexus that exists between Curitiba's bus-based transit system and its mixed-use linear settlement pattern deserves most of the credit.

Widening spatial imbalances in where Chinese urbanites live, work, and shop is widely considered to be a significant contributor to increase car-dependence and traffic congestion. Qing Shen documented increases in average travel distances in metropolitan Shanghai, from 6.2 kilometers in 1981 to 8.1 kilometers in 1991.[29] "Pull factors", like rising household incomes and the accompanying demand for housing space, partly explain urban expansion and lengthening of journey distances. But also contributing have been "push factors" like the disappearance of enterprise-based housing and labor-market liberalization, meaning low-skilled, low-waged workers are being uprooted from the central city and relocated to the metropolitan periphery. Land price differentials between central cities and suburbs have increased markedly since China's economy has become more market oriented; as a result, only businesses and industries can afford many central-city locations, marginalizing moderate-wage households to outlying areas.

5. Demand Management Initiatives

On the transportation demand management (TDM) front, Chinese cities have also made headway in recent times. Traffic restraint initiatives, like vehicle license-plate rationing, are found as are various forms of vehicle registration subscription fees that ratchet up the cost of vehicle ownership and usage. Regulations have also been introduced to control traffic that is thought to disproportionately contribute to congestion and to improve public safety. Guangzhou and Beijing no longer license motorcycles; Shanghai has banned bicycles assisted with diesel engines from urban areas and rations private cars and motorcycles through auctions (similar to Singapore). Shenzhen and Nanjing have removed hundreds of minibuses and jitneys from city streets in a campaign to reduce over-competition and favor bus operations. These demand-management strategies generally appear to be paying off. In other areas of demand management, such as the promotion of ridesharing, carsharing, and congestion-pricing, relatively little has been implemented in Chinese cities. In these areas, Chinese planners could learn considerably from the experiences of other global cities.

5.1 *Ridesharing*

America is known internationally as having made good progress in promoting its own unique form of "mass transportation" – individuals sharing vehicles to get to places, notably to work. Historically (and particularly during the energy crises of the 1970s), formal carpooling and ridesharing programs have been organized and managed through employers; Federal clean air legislation also placed considerable burdens on employers to prod their workers to share rides. In more recent times, carpooling has been organized across employees through regional ridesharing agencies.

Houston's HOV Network. One of the most effective ways of spurring carpooling in America has been through the dedication of special carpool/vanpool lanes, called High-Occupancy Vehicle (HOV) lanes. Houston, Texas has embarked on the build-up of a massive HOV program aimed at rewarding carpooling. During peak hours, Houston's 150-kilometer HOV network moves between 96 percent (Gulf freeway) and 228 percent (Katy freeway) more persons per lane than general-purpose freeway lanes. Carpools make up 94 percent of the 38,000 daily vehicles that occupy Houston's HOV lanes. While buses comprise just 3 percent of the total, they account for 34 percent of the 80,000+ daily passenger throughput. High ridership is mainly attributable to travel time savings -- average bus speeds have nearly doubled, from 26 mph to 49 mph, among express routes that switched to HOV facilities. In all, about 5 percent of the region's workforce uses HOV lanes each workday.

Houston's polycentric settlement pattern has helped sustain, and has been reinforced by, the HOV network. Greater Houston has some 22 many widely dispersed suburban activity centers, also called "edge cities. Subcentering has produced a "many-to-few" pattern of commuting, well-suited to ridesharing. As importantly, many subcenters control parking. At the TMC (the world's largest medical complex with over 60,000 workers), parking is expensive, comparable to what it costs downtown. Moreover, the TMC's parking garages lie on the periphery, whereas buses and vanpools provide near-door delivery. Most TMC employers underwrite commuting expenses of employees who share rides.

Equally important to Houston's HOV success has been good design -- long mainline segments and supporting armature. Most HOV lanes begin upstream of radial traffic congestion, beyond the inner beltloop (I-610), providing long stretches where significant time savings can accumulate. Fly-overs and ramps link 31 park-and-ride lots (Figure 9) and 19 transit centers to HOV lanes. Park-and-ride lots provide convenient staging points for forming pools, particularly important given Houston's low residential densities.

In Houston, ridesharing, and especially vanpooling, is actively promoted by both the public and private sectors. Some 2,500 vanpools, among the largest fleets anywhere, today operate throughout greater Houston. Many are sponsored by employers. The regional transit agency, METRO, itself underwrites over 100 vanpools. In Houston, one only needs to telephone or register on-line to find a rideshare partner, and efforts are

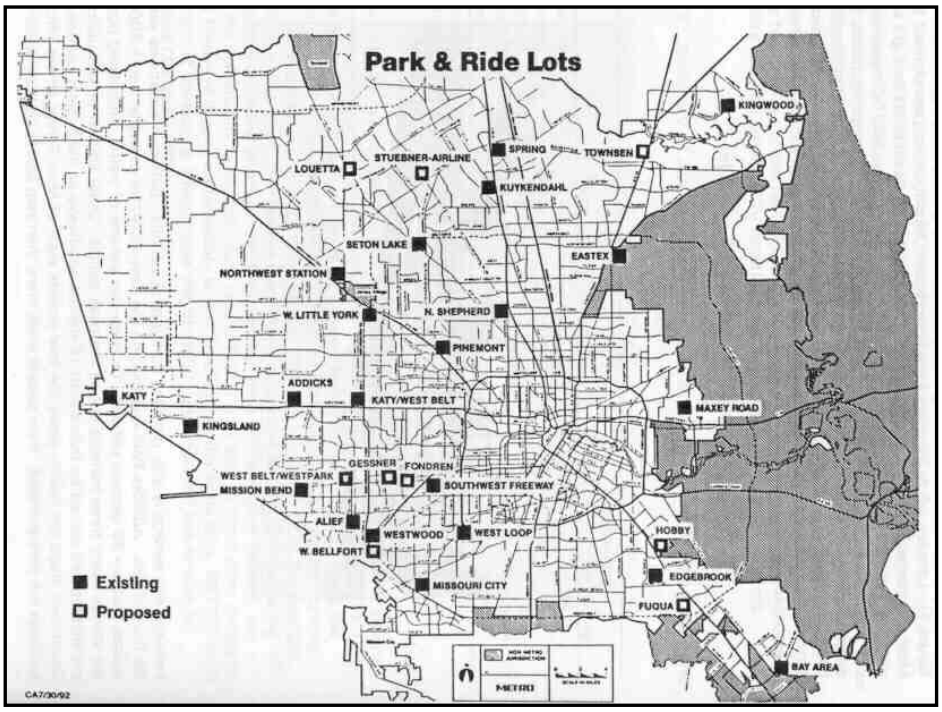


Figure 9: Houston's Network of HOV Park-and-Ride Lots

underway to one-day match carpoolers real-time using GPS (Global Positioning System) and automated vehicle dispatching and routing technologies. Good HOV services and marketing have garnered public support. Surveys show 70 percent of general freeway travelers view HOV facilities positively.

HOT Lanes in Southern California. Despite their progress in cities like Houston, HOV lanes have come under attack in recent times in parts of America. This is partly because travel complexity has made ride-matching difficult in spread-out American cities, eroding the market share of trips in carpools and vanpools. Critics charge that HOV lanes are often grossly underutilized, and have thus failed to relieve congestion or improve air quality, as promised.

The one initiative on the horizon that offers the greatest salvation for struggling HOV facilities is High-Occupancy Toll, or HOT, lanes. Pioneered in Southern California, HOV lanes allow SOVs and two-person carpools to travel on underutilized HOV+3 lanes for a fee. Because they offer value for a price, the approach is also referred to as "value pricing". By providing motorists with a choice, they put a positive spin on road pricing.

In a way, HOT lanes represent a market-based compromise between HOV and general-purpose lanes in heavily trafficked corridors. They also have political appeal. By

rescuing underutilized HOV lanes, they defuse political opposition. They also generate extra revenues which, among other things, can go to rideshare promotion.

Experiences show that HOT lanes are cost-effective -- they increase average speeds and throughputs on both special and regular lanes. People like them not only because they are faster, but also because they are more predictable and less stressful than mixed-traffic lanes. Even truckers like them once they realize that HOT lanes can assure more reliable just-in-time delivery.

America's first HOT lane facility, State Route 91 in Orange County, opened in late 1995. Built by a private consortium, SR-91 features four fully protected center-lanes (two in each direction) that span Costa Mesa and the Riverside County boundary, a distance of 10 miles. Vehicles with three or more passengers travel for free, SOVs pay tolls exceeding $3 in the peak, and two-person carpools pay around half as much as SOVs. Toll schedules are set in advance, with rates changing according to time of day. Proponents maintain that an HOV+2 facility along SR-91 would be less successful because it would not siphon off as many SOVs, which constitute the bulk of traffic diverted from general-purpose lanes. An even more sophisticated HOT-lane initiative has been introduced along San Diego County's Interstate-15, long a conduit to affordable housing to the north. There, dynamic pricing has been introduced wherein tolls vary in real time according to congestion levels, ranging from 50 cents to $4 in the peak.

The most common criticism against HOT lanes is that they are elitist. Dubbed "Lexus Lanes", critics contend that only the rich can take advantage of them. The fact is, they provide everyone with more travel choices, something that is in short supply. A working mom who is running late in picking up her child after work is apt to pay a $3 toll than face a $10 late penalty. Besides, if Americans can choose among multiple classes of services for air and train, why should they not be able to do likewise for metropolitan travel? Regardless of what elitist claims, users give HOT lanes high marks. A 2001 survey found 91 percent of motorists traveling the I-15 HOT-lane corridor supported choice afforded by HOT lanes.

5.2 *Carsharing*

Carsharing is eminently popular in many parts of Europe, but has also recently gained a strong foothold in several American, most notably Boston, San Francisco, and Portland, Oregon. U.S. experience suggests that carsharing promotes "judicious mobility" as well as vehicle-shedding and over time serves to moderate motorization trends. In a recent evaluation of San Francisco's City CarShare program, I found that vehicle kilometers traveled (VKT), adjusted for vehicle occupancies and engine-size of automobile trips, generally rose faster for those who joined City CarShare than a control group.[30] Given that around two-thirds of surveyed City CarShare members come from zero-car household, the sudden availability of cars likely stimulated automobile travel for some. Motorized travel appeared to replace some trips previously made by foot or bicycle. Presumably carshare trips have high value-added in that members pay market-rate prices for use of cars. The majority of carshare trips did not correspond to the peak periods,

suggesting many carshare trips did not contribute to traffic congestion. "Judicious automobility" should be looked upon in a positive light since travel desires are being met while keeping the population of private cars lower than it otherwise would be.

As carsharing matures and its membership becomes more mainstream, travel-behavior impacts appear to be changing with time. Evidence from a second-year survey suggests this is indeed the case. Over 70 percent of San Francisco City CarShare members had gotten rid of a car or forwent the purchase of a new car by year-two. Travel-diary data suggest VKT per capita went down almost twice as fast as for carshare members as for a control group (for weekday, workday travel). These findings suggest the availability of a shared car has spurred significant numbers of San Francisco households to get rid of a second car within 24 months, and that this in turn spurred more efficient travel and perhaps occasional foot and bicycle trips for in-neighborhood convenience shopping. These results suggest that as new members are drawn from the ranks of car-owning households, the relinquishment of private cars will eventually suppress motorized travel. Innovative, market-oriented car-based strategies like carsharing (along with station cars) hold considerable promise in good part because they respond to shifting demographic and urbanization trends.

5.3 *Road Pricing*

Lastly, "getting the prices right" has long been recognized as an essential element of any economically sustainable transportation program, and in this regard, Chinese and other cities of the developing world can learn a lot from places like Singapore and London. As noted earlier, Singapore's success with electronic road pricing stems in large part from its aggressive stance on transit-first policies and TOD. Having a transit and land-use arrangement that offers a respectable mobility option to private automobile travel has been essential in building the social and political capital necessary to sustain electronic road pricing in Singapore.

In early 2003, London joined the ranks of Singapore when it introduced a central-city cordon-area pricing scheme. The entry charge of 5 pounds per day has reduced traffic volumes in central London by around 20,000 cars per day. Average travel speeds have risen from 12 to 18 kph.[31] Also, bus ridership increased by 14 percent (in part because of a major expansion in bus service) and underground ("The Tube") patronage has inched up by 1 percent (limited by capacity restraints). There has been a 10 percent increase in traffic on peripheral roads, however delays have not risen. Public sentiment has swung from considerable opposition to major support.

6. Lessons for China and the Developing World

As Chinese cities continue to modernize and develop at a rapid pace, Chinese planners are in a position to learn from the experiences of other global cities and mobilize resources in the urban transport sector to place cities on sustainable pathways. Initiatives like "transit first", jobs-housing balance, TOD, ridesharing, and road pricing have

potentially significant roles to play in creating a more balanced, multi-modal transportation program – one that embraces not only principles of mobility and efficiency but also ones of environmental sustainability, social equity, accessibility, and livability.

Some factors are working in favor of balanced, multi-modal transport and urbanism in Chinese cities. Strong centralized planning and a unified metropolitan administration provides a streamlined institutional environment to conduct regional-scale coordinated planning. Small, sub-metropolitan jurisdictions rarely have the resources, wherewithal, or political mandates to strategically plan for integrated transport and urbanism. A China's legacy of centralized planning means land-use and structural adjustments can be introduced relatively quickly. So can sometimes politically controversial measures like electronic road pricing.

Also, China's citizens seem receptive to measures that curb car dependence. In 2004, two southern Chinese cities – Chengdu and Shenzhen -- held the country's first "car free" days. Shenzhen's campaign was in response to rapidly declining air quality. To show their support for car restraint measures, more than 100,000 residents of Shenzen opted walk, bike, or take transit to work, and leave their cars at home.

China has shown a penchant to innovate, making progress in introducing sustainable technologies. CNG conversions means many urban bus fleets operate on relatively clean fuels. Cycling lanes and pedestrian provisions remain generous by international standards. Public spaces are being reserved for pedestrians and nature. Using buffers and landscaped wedges, the city of Shanghai aims for 35% of the city's land to be covered by greenery by 2020; the public green space per capita is to increased to 10 square meters.

Perhaps working most in China's favor is that fact that it is still relatively early in its stage of modernization and expansion (though the window of change is rapidly closing in global megacities like Shanghai and Beijing). Decisive action how can have lasting influences on both transport systems and urbanization patterns.

Notwithstanding the many factors working in China's favor, many obstacles stand in the way of a more balanced, multi-modal approach to transport development. One constraint is the absence of a stable funding source for public transport. Most transport monies go to roads; public transit investments must rely on foreign loans and land concessions. Additionally, public transit planning is short-term and operational in focus. Usually, independent bus companies concentrate on purchasing rolling stock and expanding route coverage; little attention is given to coordinated land development or even technology.

It is critical that Chinese cities pursue a balance of demand-side and supply-side solutions and accessibility as well as mobility-based transport policies in coming years. Such a multi-modal, balanced approach to transport and urbanism will be the linchpin to placing cities of the most populous nation on earth on a sustainable trajectory, economically as well as environmentally and socially.

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