SUSTAINABLE
CITIES CHINA

DESIGN MANUAL

FOR LOW CARBON DEVELOPMENT

THE ENERGY FOUNDATION

CHINA SUSTAINABLE CITIES PROGRAM

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EXECUTIVE SUMMARY

This document lays out some simple principles and practices focused on making China's development patterns more sustainable, resilient, and energy efficient. It reframes critical elements of city development into mixed-use, walkable and transit oriented districts and neighborhoods. It proposes to overlay a different development pattern in residential and key commercial areas in order to support a larger range of travel modes, and create areas with more social and economic vitality.

This involves creating a new set of land-use and circulation standards that will generate urban places capable of rebalancing the role of transit, pedestrian, bike, and vehicle use in Chinese cities. Currently the trends throughout China show a dramatically increasing dependence on auto use. This is more than the manifestation of a simple market preference; it is the result of land-use patterns and street network design that makes alternatives to the car less and less desirable. As walking and biking become more dangerous and inconvenient, and as transit becomes less accessible, city districts naturally become more auto-oriented. But at the densities of Chinese cities, such dependence quickly becomes unsustainable; congestion, air quality impacts, infrastructure and costs rise dramatically.

The alternate is to create a new DNA for the next generation of China's city development. One that limits the growth in auto mode split and kilometers driven per capita naturally by providing alternates that are safe, convenient, and cost effective. If each city sets a simple policy establishing goals for the mix of transportation modes in its circulation system, then the city's design and infrastructure investments can be shaped to achieve that outcome.

The approach described here operates on two scales, City Master Plans and Regulatory Plans, and in two domains, circulation and land use. At the scale of City Master Plans new walkable, mixed-use 'Transit Oriented Districts' (TODs) can be added to existing zoning maps at key transit, residential, and commercial focal points. These will become urban districts and residential areas that are more walkable, bikeable, and transit oriented. At the Regulatory Plan scale these new TODs are then translated into standards and land-use patterns that detail the critical design features that support such urban places.

Each scale needs a different set of zoning and urban design standards to mix uses in effective proportions, activate the street with pedestrians, and focus intensity around major transit stations and corridors. This change in land-use mix and urban design must be complimented by a new circulation system; one that balances the needs of the pedestrian and biker with efficient auto access at the same time it reinforces transit. This new circulation system involves creating more robust circulation networks, a broader range of road types, and street sections that generously accommodate multiple modes.

Reducing auto dependence and energy use involves shaping cities that provide more choices in travel behavior while increasing accessibility rather than just mobility. This translates into a cluster of strategies; creating land-use patterns that shorten trip lengths and create the kinds of environments that foster linking multiple destinations into one trip. It means increasing pedestrian convenience, which then makes transit trips more accessible and timely. Three fundamental aspects of travel are affected by urban form -- mode split, average trip length, and the number of daily trips per household. Walkable and mixed-use districts centered on major transit stations help in all three measures: better mode shares to pedestrian, bike and transit are facilitated in more walkable environments, trip lengths are shortened as uses are mixed, and the trip quantities are reduced as destinations are combined.

This manual is developed in two sections, one on circulation and one on land use and urban design. But these sections cannot be considered independently - both are deeply interconnected. In fact, too often the lack of connection between different land-use forms and complimentary circulation systems is a big part of the problem with city building in our time. Generic street types, keyed more to auto speed and capacity than urban context have frequently negated the complex character of city streets and the many integrated social and economic functions they perform. Conversely land-use that is not scaled to transportation capacities, particularly the capacity of transit systems, too often creates tenacious traffic and mobility problems.

The form of streets and circulation networks must change in differing urban contexts just as the land-use intensity and mix must respond to differing circulation capacities and technologies. Areas that have high levels of transit service should be designed as 'Transit Oriented Districts' (TOD) while intensive mixed-use areas should have adequate transit facilities. This is, simply stated, the goal of this manual.

At the Master Plan level key areas that should be converted to or developed as 'TODs' (those that are to be mixed-use, transit intensive and higher density) are identified in relation to the level of high capacity transit service planned for the area. Those areas with high levels of transit investment logically should provide environments designed for easy pedestrian movements. Those areas without major transit investments and are dedicated to low intensity, single uses such as manufacturing, warehousing, light industrial or institutional uses should not be designated as TOD Districts. Therefore many single-use areas will remain unchanged while the majority of new residential and office employment areas should be transformed.

These TOD Districts are then zoned with three mixed-use 'place-types' keyed to the specific level of transit service. The higher the transit capacity the denser and more commercial the land-use of the center. For example an area with two metro lines crossing would have the highest urban designation with a focus on office jobs, intensive housing and regional serving retail. In contrast, an area served by a single BRT line would primarily be residential with local serving commercial uses mixed in.

The Regulatory Plan would then redesign these 'TOD Districts' with street networks designed to accommodate more pedestrian, bike and transit activity. This modified street system is called the 'Urban Network' and typically involves a denser grid of narrower streets resulting in smaller city blocks. In addition these district's land-use and urban design standards are modified to create more integrated and mixed-use areas. This is accomplished by a zoning system using a menu of mixed-use 'small blocks' rather than the typical single-use land-use zones. Each 'small block' has a range of uses and intensities, and has a set of urban design controls to insure that streets are activated and well defined as useable public space.

In sum, the methodology involves the following steps:

1. Identify potential 'TOD Districts' within the City Master Plan based on levels of transit investments and type of land use.
2. Within each TOD, zone for three types of 'Centers' keyed to their transit capacities.
3. Modify the circulation system within these TODs into an 'Urban Network' configuration to be more pedestrian, bike and transit friendly.
4. Employ new mixed-use 'Small Blocks' zoning with specific land-use and urban design standards to create more walkable urban environments.

I INTRODUCTION

INTRODUCTION

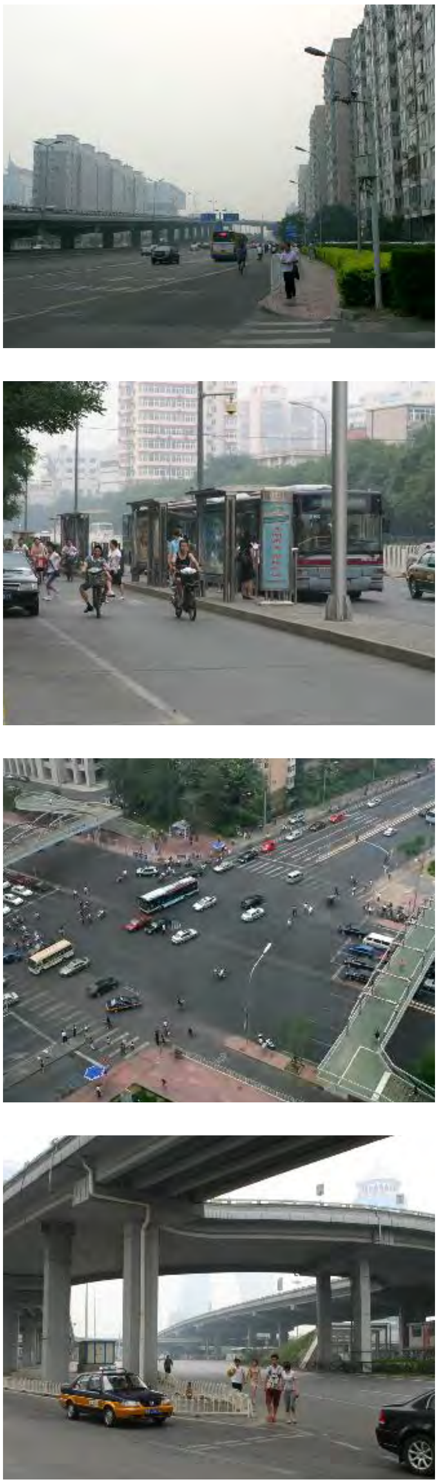


Figure 1.1: The Superblock Grid with wide streets and intersection crossing distances creates an unsafe and inhospitable pedestrian environment

As China continues its impressive economic growth, unprecedented numbers of its citizens are migrating to cities, seeking greater job opportunities, income, and a higher quality of life. Car ownership is on the rise, and China has already passed the United States as the largest car market in the world.

Similar to U.S. cities in the 1950s and '60s, Chinese cities are working to accommodate the explosive growth of automobile travel by building highways, ring roads, and parking lots. However, due to China's high population density, the problems of private-car-oriented transportation are much more acute than in the lower density cities of the West. For example, traffic in Beijing is frequently at a standstill despite the incredible pace of new road construction. And in Shanghai, projections show that car use will need to be restricted and transit, bike, and pedestrian mode share increased to improve mobility and bring congestion back to a manageable level. The reality is that high-density cities cannot be designed around the car. It simply won't work.

China's leaders have a limited window of opportunity to plan for prosperous, livable, low-carbon cities. These cities must make public transport, walking, and bicycling their top priorities. Without this planning, these burgeoning cities will not reach their full potential. They will be gridlocked and polluted. The commutes of millions of people will become a daily misery, countless square kilometers of arable land will be needlessly lost, and China's powerful economic engine will stall as goods and people become mired in congestion. In these conditions Chinese cities will struggle to attract the high-tech businesses and the top-notch talent that are crucial to maintaining economic growth.

In fact cities throughout the world are facing a crisis of profound economic, ecological and social dimensions, largely brought about by a way of life that leads to excessive carbon emissions and subsequent climate change. It is now an undisputed fact that if the current pattern of growth is allowed to continue unchecked, the impact on the environment will be drastic and largely irreversible, impacting the lives of everyone on our planet. Carbon dependence has to be reduced and sustainable city design can play a central role.

Two factors that have played a major role in effecting climate change are urbanization and transportation. In the west the current environmental crisis is largely the result of how cities have been built over the past fifty years, leading to excessive auto-dependence for mobility and rampant sprawl using up precious land. It is imperative that China not follow this pattern of auto oriented urban growth and instead adopt a model that has lesser impact on the environment.

China as one the world's great emerging economies is at a critical juncture in its history. Its urban population is projected to grow by 300 million by 2025. This urbanization is happening at an unprecedented speed and scale, fueled by a booming economy. Choices made now will have an immense impact on the long-term viability and energy efficiency of its cities. China has to choose - creating cities that are livable, efficient and environment friendly through a new approach;

or a continuation of outdated planning ideas that reinforce auto use, reduce quality of life for the pedestrian, isolate residential communities, and compromises the environment.

The form of China's urban growth will also shape much of the country's long-term environmental demands and impacts. Transportation, for instance, now represents 85% of the country's petroleum consumption, and is its fastest growing sector. As the country's urban patterns reinforce auto use through more freeways, large arterials and superblocks, walking, biking and transit are declining. In Beijing since 1986 auto use has increased six fold while bike use has been cut from nearly 60% of all trips to just 17% in 2010. The congestion, air quality, and greenhouse gas impacts of such a shift are massive.

In addition injuries for drivers, pedestrians, and bikers are on the rise, the bicycle-related mortality rate has increased 99% from 1992 to 2004. Every day 300 people die in traffic accidents in China, the highest rate in the world – and the number is increasing about 10% per annum. The underlying case of these trends is no mystery. Studies in Jinan show that there is a fivefold increase in household vehicle kilometers traveled (VKT) between a mixed-use traditional street grid neighborhood and a newer single-use superblock configuration.

Although China is investing in transit, its contemporary land-use pattern reinforces auto use, creates pedestrian barriers and increases dangerous bike environments. Walkable neighborhoods, in addition to being essential to great urban places, are key to transit use as every transit trip starts and ends with the pedestrian.

The current pattern of development being followed in China can be termed the 'Superblock Model'. Based on a network of wide arterial (high-capacity) streets, it features large development blocks, as the name suggests, often 500 m by 500 m in size. The Superblock Model typically lays emphasis on moving cars efficiently, often at the expense of pedestrian safety and bike movement. To counter the problems of these wider streets, building setbacks further separate uses and distance pedestrians. This combination of factors hinders the pedestrian environment, bike safety and reduces 'walkability', in turn affecting retail activity and transit usage.

The main design criteria for active, vibrant urban communities is to design around the pedestrian, bike and transit, not the car - in other words, design using narrow streets and small blocks, with active, useful and interesting edges.

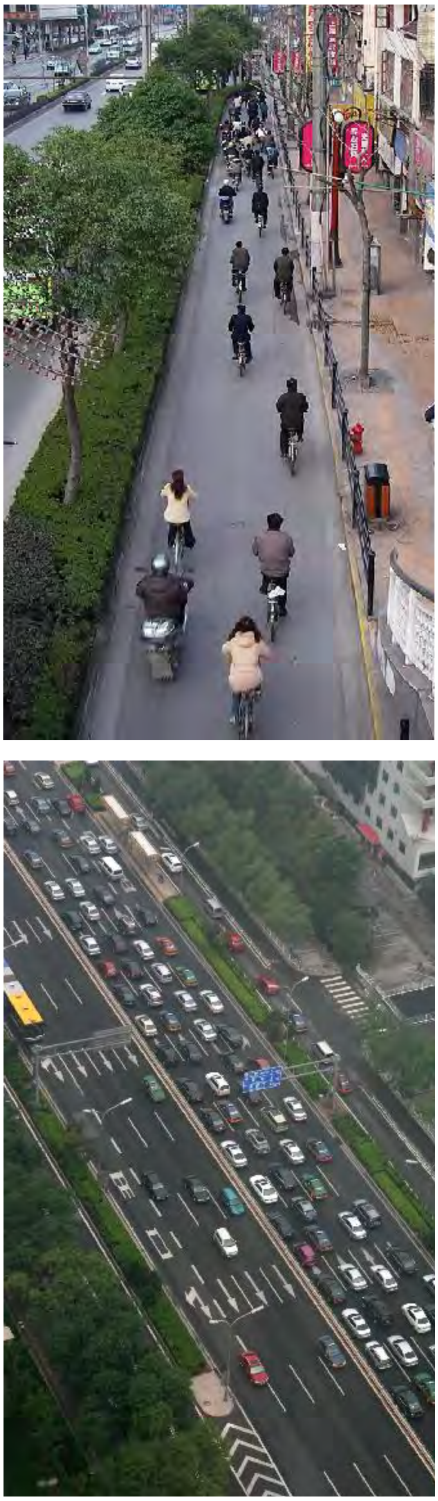


Figure 1.2: As more cities are designed to accommodate the car, he modal share of bikes continues to decrease.

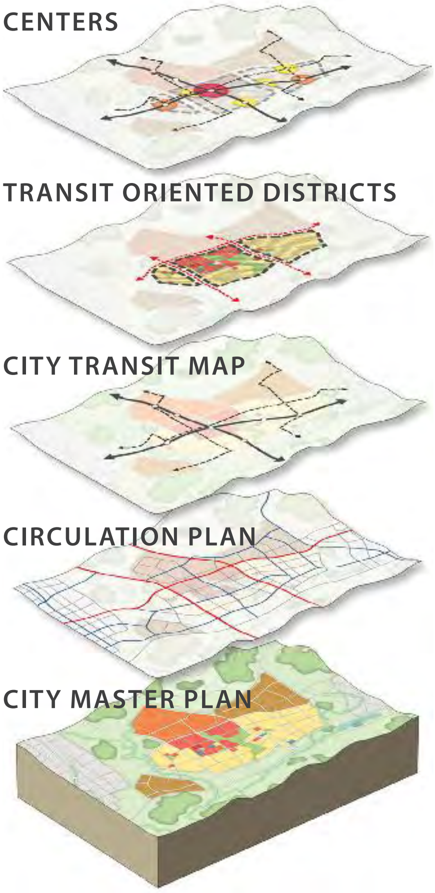


Figure 1.3: Transformation of a City Master Plan into TODs

Reducing the carbon footprint and foreign oil dependence in cities depends on efficiencies in three areas; transportation, buildings, and infrastructure. While this manual is primarily concerned with the transportation implications of differing urban forms, the other two factors, buildings and infrastructure are equally important. Climate responsive architecture with intelligent building technologies can go a long way in reducing electric and heating oil demands. Comprehensive community infrastructure such as waste to energy power plants and co-generation systems can augment these savings.

But reducing energy use in the transportation sector is particularly important as it has so many complimentary benefits; as auto dependence is reduced oil demands go down, congestion is relieved, air quality improves, transit systems become more efficient, and household transportation costs are reduced. More walking and biking also leads to a healthier population, safer streets, and more vital urban environments. Such changes involve reconfiguring the land-use, urban design, and circulation systems of city planning in a comprehensive and interconnected manner. This manual outlines an approach to this challenge.

With the standards and practices presented here, Chinese decision makers can leapfrog over some of the world's urban planning mistakes and establish a new paradigm for the cities of the future.

Benefits of sustainable urban planning are:

- Improved mobility
- Reduced carbon emissions
- Increased economic activity
- Improved air quality
- Preserved arable land
- Support for a healthy, harmonious and prosperous society

DESIGN PRINCIPLES FOR LOW CARBON CITIES

The following eight principles of city design summarizes the key strategies for developing urban districts than can reduce carbon emissions, improve air quality, and create economically vital cities as China grows. They are developed from international best practices as they apply to China. When applied together, we believe they will help China create beautiful, thriving cities that will be models of smart urban development for the rest of the world. These principles depend on and reinforce each other. Different cities can adopt differing mixes and priorities from the eight, but they are intended as pieces of a whole. Together, they are a recipe for success. They define the principles, purpose, and goals for the standards and practices described in this manual.

These principles are based on much research within the planning profession that has led to a key list of metrics that have been shown to significantly impact travel behavior. In fact, they are the variables typically used in most travel simulation models. These metrics have been applied to the specific circumstances of growth in Chinese cities, then translated into the following principles, then the methodology and standards outlined in this Manual. The metrics are briefly discussed and then the principles are described.

The principles introduced here represent what some of the worlds' leading experts believe to be best practices in urban design. Cities are gradually adopting these measures, but those that have embraced them are the most livable and economically secure cities in the world. These principles support each other. Blocks with mixed uses encourage walking, and walkable cities create customers for local businesses. Smaller block sizes encourage bike and pedestrian use, which cuts down on traffic, allowing public transit and automobile traffic to run better; and so on. Enacting all eight principles is the key to a sustainable, livable city.

The practices and standards outlined in this manual provide a toolkit to implement these principles. The 'Urban Network' circulation system provides an approach to creating a street system that balances the needs of cars, commercial vehicles, pedestrians, bikes and transit. The 'Transit Oriented District' zoning overlay provides a land-use approach to locate and design more mixed-use, walkable, and transit receptive land-use patterns. The three 'TOD Center' designations helps to focus jobs and high density housing in the most efficient and logical locations throughout the City Master Plan.

While these principles are a synthesis of international best practices, China's challenges and opportunities are unique. Many of these recommendations are not consistent with current planning rules and regulations. It is time to apply cutting-edge scientific thought about what makes cities successful and to reexamine our cities in light of this most recent understanding. China has the resources and vision to leapfrog over the rest of the world and create the best cities of the future. Now is the time to seize this opportunity and lay the foundation for a healthy future.

The metrics are:

Density: Higher overall density of housing and jobs has long been correlated with lower auto use and more walking, biking and transit use. China is currently very strong in this area, developing new sections of its cities at very high average densities.

Diversity: The more mixed-use an area the greater the opportunity for local trips on foot and the shorter the trip length. Traditionally Chinese cities and districts where mixed and diverse, but recent development patterns have shifted to the international norm of isolated land-use zoning.

Design: Mix and density are not enough if the design of the streets and building frontages do not support easy and convenient pedestrian mobility. A walkable district has active and useful edges and short, safe street crossings. The design of Chinese neighborhoods has grown increasingly inhospitable to pedestrians and bikes, as buildings and shops have retreated from what traditionally were public spaces designed for street life and activity.

Destination Accessibility: The placement of regional destinations such as job centers and major institutions in areas well served by transit has a major impact on travel to work mode split, peak hour congestion, and overall auto use. Access to major job centers in Chinese cities is becoming a crisis as commercial development is clustered in districts too large and dense to be served by auto or transit.

Distance to Transit: The level of transit service, its headways, capacities, multi-modal connections, and overall ease of use impact the key metric of mode split. If transit stops are too far from home, if the service is infrequent, if the travel time is slow, the use of transit will decline. Most large Chinese cities are aggressively investing in robust transit service, while small and medium cities often lack adequate service. Bus service on mixed streets is often slow and contributes to congestion.

Demand Management: The relative cost of different forms of mobility impacts transportation choices powerfully. Parking costs, road and bridge fees, and district access limits can all play a significant role in travel behavior. Few Chinese cities employ such demand management strategies, however they will become necessary as auto ownership grows while land use polices remain unchanged.

Demographics: The type of household, average age, and its income has a big impact on auto ownership rates and the average distance traveled per household. Providing affordable housing in areas well served by transit and local services allows lower cost transportation choices. As China becomes wealthier and its urban middle class grows, its demographics will stress its transportation systems dramatically.

The following eight principles are a result of considering these metrics in the context of growing Chinese cities. The Transit Oriented Districts (TODs) described later in this manual combine and realize all of the goals, practices and standards advocated in these principles.

The eight design principles are:

1. DEVELOP NEIGHBORHOODS THAT PROMOTE WALKING
2. PRIORITIZE BICYCLE NETWORKS
3. CREATE DENSE NETWORKS OF STREETS AND PATHS
4. SUPPORT HIGH QUALITY TRANSIT
5. ZONE FOR MIXED-USE NEIGHBORHOODS
6. MATCH DENSITY TO TRANSIT CAPACITY
7. CREATE COMPACT REGIONS WITH SHORT COMMUTES
8. INCREASE MOBILITY BY REGULATING PARKING AND ROAD USE

1 DEVELOP NEIGHBORHOODS THAT PROMOTE WALKING

Figure 1.4: Ground-floor retail encourages walking

Figure 1.5: Pedestrian-friendly streets in New York City

Figure 1.6: Pedestrian activity, as shown here in Chongqing, China, creates community and supports business

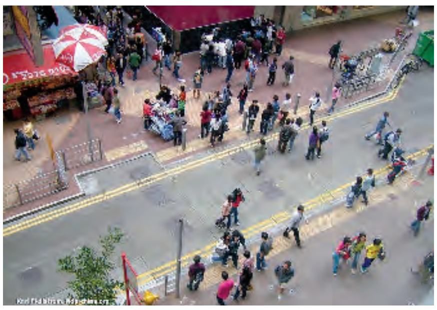


Figure 1.7: Design features in Hong Kong slow traffic and keep pedestrians safe

Walkable streets and neighborhoods are the foundation of every great city. Walking reduces auto dependence, supports public transit, improves health, and promotes community. Simple measures - such as limiting road width, block lengths, and setbacks between buildings and sidewalks - encourage walking. Sidewalks that feature amenities like shade, benches, and street lighting also encourage foot traffic.

Designing streets that are safe to cross and providing comfortable, interesting places to walk should be the first priorities for establishing livable, low-carbon cities.

A] Shorten street crossings and emphasize pedestrian safety and convenience.

- Limit street widths to 45 meters for through traffic (50 meters with BRT) and 25 meters for local access.
- Create direct routes and permeable blocks by limiting average block length to 150 meters in new development and creating public paths through existing superblocks.
- Provide safe, well-defined and uninterrupted pedestrian zones at least 3 meters wide on each side of every major street.

B] Encourage ground-level activity and direct pedestrian access along every street.

- To encourage sidewalk activity, visibility and safety, buildings with public uses and shops should front the sidewalk and residential developments should have multiple access points.
- Perimeter security walls should be set back from the street fronting buildings or be replaced by see-through fences.
- Limit the distance between buildings and the sidewalk to the following averages: Retail: 1 meter; Offices and businesses: 3 meters; Homes and apartments: 5 meters.

PRIORITIZE BICYCLE NETWORKS 2

In the 1980s, millions of Chinese people depended on bicycling as their primary mode of transportation. Bicycling is no longer safe or convenient in many Chinese cities. In recent years, cities across the globe have been working to reintroduce bicycles as an integral part of city life because they are a simple, inexpensive, and low-carbon way for city residents to travel between destinations, including transit stations. To ease congestion, Chinese cities must once again encourage cyclists by providing safe conditions, including bike lanes and secure bicycle parking.

A] Design streets that emphasize bike safety and convenience.

- Create dedicated and protected bike lanes, at least 3 meters wide in each direction, on all streets except low-speed local streets.
- Provide secure bike parking in buildings, on streets and at transit stations.

B] Create auto-free streets and greenways to encourage non-motorized travel.

- Establish car-free corridors across the city grid, no more than 800 meters apart.
- When combined with transit and pedestrian-only streets, bike lanes should be protected.

Figure 1.8: Bike lanes should be protected from car traffic

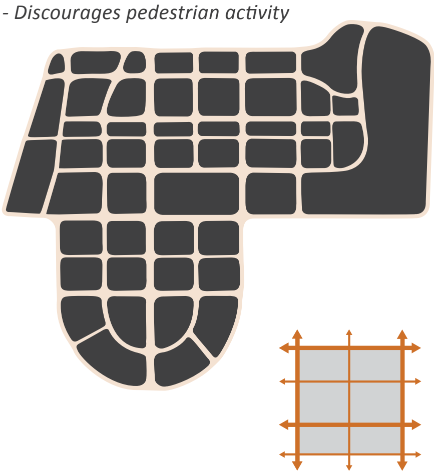
Figure 1.9: Where possible, bike parking should be included at transit stations

Figure 1.10: The Hongshou bike-sharing system is the largest in the world

3 CREATE DENSE NETWORKS OF STREETS AND PATHS

DISCOURAGED:
Arterial-dominant Superblock network

- Prioritizes cars over people
- Discourages pedestrian activity



RECOMMENDED:
Urban Network of smaller blocks

- Prioritizes people over cars
- Supports pedestrian and economic activity

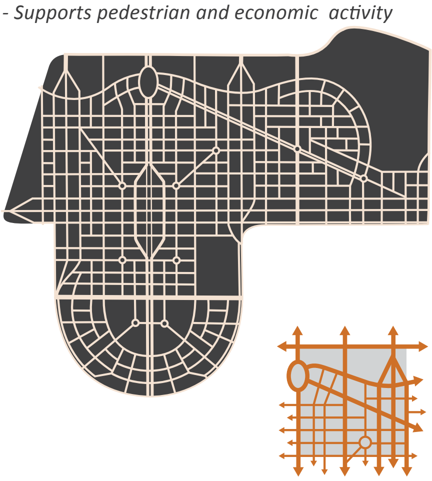


Figure 1.11: Comparison of a typical superblock grid with arterial streets with the recommended urban grid of smaller blocks and a dense network of narrower streets

It is a common misconception that wide streets are more efficient and improve traffic flow. In fact, gated superblocks divided by wide roads actually contribute to China's traffic congestion. Case studies show that a denser network of narrower streets better optimizes traffic flow while creating more direct routes and improving safety for pedestrians. Road design should maximize human mobility rather than vehicle throughput. Narrow streets that allow one-way motor traffic as well as bicycles and pedestrians will significantly reduce congestion — and fuel use — in Chinese cities by minimizing traffic signal delays.

A] Create dense street networks that enhance walking, bicycling and vehicle traffic flow.

- Plan for a minimum of 50 intersections per square kilometer.
- Limit traffic speeds on local streets to 40 km/hour.
- Design local streets with traffic-calming features to help enforce speed limits.

B] Disperse high traffic volumes over narrow, parallel routes rather than concentrating on major arterials.

- Create a grid of varied street types to provide multiple parallel routes for all types of traffic.
- Incorporate through-roads that connect adjacent neighborhoods at least every 300 meters.
- Replace major arterials wider than 45 meters with efficient one-way couplets (two narrower one-way thoroughfares).

SUPPORT HIGH QUALITY TRANSIT 4

Hong Kong, New York City, Singapore and other affluent cities have the densest public transit networks in the world. While metro can be an integral part of a transit network, a growing number of cities are turning to bus rapid transit for its low cost, quick implementation, and flexible routes. Each Chinese city will need to determine the appropriate mix of transit solutions for its conditions, but cities can guarantee the overall success of their transit by providing frequent, fast and direct service in easily accessible locations.

A] Ensure frequent and direct transit service.

- Establish a grid of high-capacity, high-speed transit corridors approximately every 1000 meters with dedicated transit lanes.
- Provide an integrated multi-modal system and ensure seamless transfers to all available transit options. Minimize the number of transfers needed for most passengers.

B] Locate transit stations within walking distance of homes, jobs and services.

- All major housing and job centers should be within 400 meters of a local transit station and 1000 meters of regional transit service.
- Increase density and ground floor services adjacent to major stations.

Figure 1:12: Modern BRT systems, like this one in Jinan, China, feature all the conveniences of metro systems.

Figure 1:13: Guangzhou before BRT (above) and after the BRT system opened in February 2010 (below)

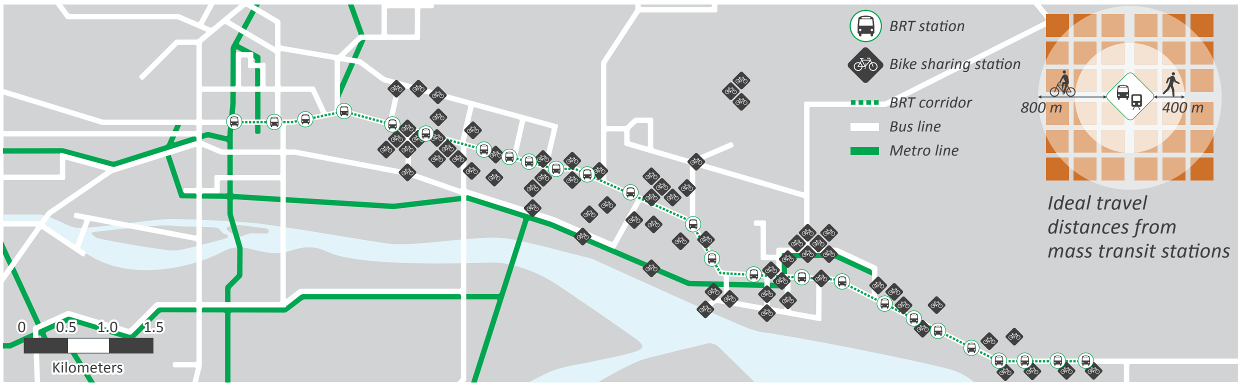


Figure 1:14: The Guangzhou BRT system map (February 2011). The BRT system moves 27,000 passengers per hour per direction during peak commute hours and integrates with bike lanes, bike sharing stations, metro lines and other feeder bus systems

5 ZONE FOR MIXED-USE NEIGHBORHOODS

Figure 1.15: Every city should feature many parks

Figure 1.16: Jing'an Metro Station (above and below) is a good example of transit-oriented mixed-use development

Traditional Chinese neighborhoods had lively streets where children played sports and the elderly played mah-jongg. These neighborhoods had problems too, but it was the lively mix of shops and services near homes and jobs that gave these areas their charm and identity. By trading traditional housing for modern apartments, the Chinese people are losing their communities' unique sense of place and the efficiency of compact neighborhoods. China's cities of tomorrow need to combine the benefits of modern housing with the best qualities of traditional urban neighborhoods.

A] Encourage an optimal balance of housing and services through zoning codes.

- Housing options should accommodate a mix of income levels and age groups.
- Shops and local services should line the ground floor of most streets fronts within easy walking distance of housing and jobs.
- Mix housing, shops and services within commercial districts to create 24 hour communities.

B] Provide a variety of accessible parks, civic clusters and open space.

- Neighborhood parks should be located within 400 meters of housing; large regional parks within 1 kilometer.
- Clusters of schools and civic destinations should form neighborhood centers within 400 meters of residential buildings. This includes age-specific services, such as day care.
- Unique natural environments and local cultural and historical assets should be preserved and creatively reused.

MATCH DENSITY TO TRANSIT CAPACITY 6

High density is crucial to low-carbon cities, but density alone is not enough. In order to avoid congestion, housing must be located close to public transit and jobs. Density also needs to be related to the capacity of all modes of transportation. If roads are designed as suggested in this guide — with bike and pedestrian-friendly corridors, transit priority lanes on major arterials, and one-way arterial couplets — activities can be concentrated to make walking, cycling, and mass transit more convenient than driving. This will shorten trip distances, save travel time, and preserve millions of square kilometers of arable land.

A] Match density to the maximum peak-hour capacity of a transit system.

- Both residential and commercial density should be designed to match the area's peak-hour transit, walk and bike capacity.
- Major job centers should only be located where high-volume transit services are available.

B] In key employment areas, zone for mixed-use districts that combine every day uses.

- A mix of recreation, services, and retail should be located in employment areas to provide for daily worker needs on foot.
- Use TOD Center standards for minimum employment and population densities at stations to reinforce demand for services, transit, and mixed-use environments.

Figure 1.17: In Guangzhou, density is focused around the BRT corridor. The system's capacity matches commute-hour transit demand.

Figure 1.18: In Curitiba, Brazil, high-rise development is focused within 200 m of transit.

7 CREATE COMPACT REGIONS WITH SHORT COMMUTES

Community location has a long-term impact on sustainability. New city centers placed far from existing cities are inconvenient and rarely thrive. City planners can avoid this by locating compact new sub-centers within or adjacent to existing cities. In addition to protecting arable land, this strategy significantly decreases the cost of providing transit, utilities, and other services to these new locations, while reducing most residents' daily commute. Decentralizing employment in locations that encourage reverse commutes will reduce peak-hour congestion on roads and transit systems.

A] Reduce sprawl by focusing development in areas close to or within existing cities.

- Regional development should seek a compact footprint through preservation, reuse, and infill of existing areas, balanced with dense areas of new growth.
- New development should avoid agricultural lands and other environmental assets.

B] Create a jobs/ housing balance within a short commute distance.

- Create multiple high capacity transit connections to all new development areas.
- Locate job centers to limit commutes to approximately 5 kilometers or 15 minutes on transit.
- Create smaller decentralized job centers that encourage reverse commutes.

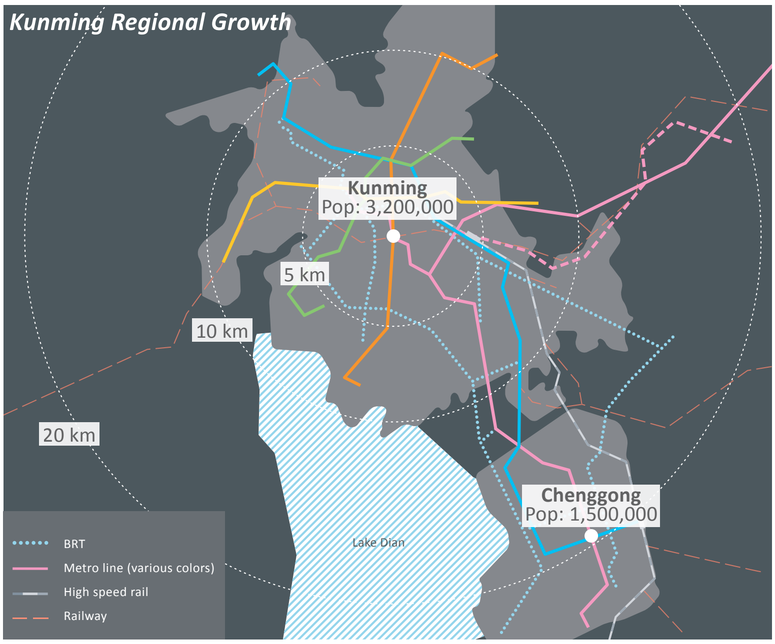


Figure 1.19: Regional planning in Kunming, China aimed at reducing sprawl and creating a jobs-housing balance.

INCREASE MOBILITY BY REGULATING PARKING AND ROAD USE

8

Avoiding gridlock requires limiting the use of vehicles to levels that the road network can support. Peak commute-hour car trips are often unnecessary and should be discouraged. There are many ways to discourage driving. London, Hamburg and Zurich, for example, restrict parking in popular destinations served by public transit. Singapore and Stockholm have implemented road-use charges. Chinese cities should consider these strategies – which complement the above principles – to help relieve their congestion problems.

A] Limit parking in key employment districts to discourage driving during peak traffic periods.

- Limit parking ratios in employment areas to 0.2 stalls per worker.
- Eliminate long-term street parking to ease congestion and reduce street width.
- Remove all parking-space minimums for residential buildings and establish city-wide parking-space maximums consistent with targets for private car use.

B] Adjust car fees by time of day and destination.

- Institute a congestion-management system that limits auto use in key urban and employment districts at peak traffic hours.
- Charge tolls for use of overloaded roads and bridges and use the fees to support transit.
- Vary parking charges by time of day and location to insure high turnover.

Figure 1.20: Cities may choose to charge tolls for use of overloaded streets. Singapore's Electronic Road Pricing system has cut congestion and raised money for public transit and other uses.

Road Pricing reduces congestion and raises money for local government. Some facts from Singapore and London:

80,000 kilograms of CO_2 emissions reduced in Singapore's traffic congestion zone

85 percent of people commuting to London during toll times now taking transit

Annual revenue raised by Singapore's traffic congestion program **330** million yuan

37 percent more Londoners riding buses during toll times than before congestion pricing

20 percent increase in Singapore public transit use since Singapore started congestion pricing

Annual operation cost for Singapore's traffic congestion program **65** million yuan

50 percent decline in bus delays in London

30 percent decrease in congestion since London started congestion pricing

THE LAND USE / TRANSPORTATION CONNECTION

In the United States and Europe, many have argued that urban growth management can be an effective way to shape peoples' travel behavior to produce less energy-consuming patterns. Conversely, skeptics argue that urban development's impact on travel demand and energy use is limited because it is difficult to change land-use patterns given relatively weak policy leverage from local governments and because cities in developed countries are largely built with an auto-oriented structure. By this argument, taxing fuel would be a much simpler, faster, cheaper, and more cost effective policy instrument than rearranging metropolitan areas and/or making major investments in transit.

China, however, is different. China is still experiencing rapid urbanization, a trend likely to continue for decades. A projected 300 million or more Chinese will move to the city in the next 15 years and the urbanization rate will increase to 60% by 2025, from 46% in 2010; at that time, there will be 221 Chinese cities with more than one million people. If travel demand can indeed be reduced through better design in the urban built environment, there is much more potential in China than in western developed countries to influence travel behavior and urban outcomes in this high growth period.

In addition, compared with many other developed countries, Chinese city governments have relatively strong control over local urban development patterns through their institutional framework and public ownership of urban land. The recent heavy investment in urban infrastructures (subway lines, bus rapid transit systems, etc.) as a component of the national stimulus package has made urban growth patterns (transit oriented development) advocated by many in the west look uniquely feasible and promising in China.

Unfortunately this opportunity for China has not been recognized. Instead, auto-oriented neighborhood development (so-called "superblock" development) dominates current urban expansion and construction. This is partly because there have been very few empirical studies supporting the efficacy of alternative urban growth patterns in China from the energy perspective. Transferring western policies and design standards directly to China without careful adaptation is viewed as risky and problematic by local leadership given the different social, cultural and institutional context. For example, the existing neighborhood density in China already greatly exceeds any density level considered in US development today. Even if the transit-oriented development concept, for example, is favorable, what kind of TOD China should pursue is still an urgent question. This cannot be answered without empirical data in the local context.

Transport Energy Use in China

The transportation sector accounts for 22% of primary energy use and 27% of CO_2 emissions in the world as of 2004, and is expected to be the most rapidly growing source over the next 30 years. In the developing countries, transportation energy use will grow at 2.7% per year from 2006 to 2030, a rate 8 times higher than the projected rate for OECD countries, and the use of fuels in the non-OECD transportation sector as a whole will nearly double over the period.

In China, the trend is more pronounced. Thanks to ongoing economic growth, urbanization and changing consumer lifestyles, oil consumption by Chinese road transport has increased by 9% per year between 1995 and 2005 (Figure 1.20), currently consuming about 85% of the total national oil consumption. In the next decades, demand is projected to continue to increase at an annual rate of 6% under current trend, triggering a quadrupling increase in oil consumption in 2030 and accounting for more than two-thirds of the overall increase in national oil demand.

This rocketing transport energy use adds uncertainty to China's future growth, because the country has relatively limited petroleum resources compared to other energy sources like coal. Measured on a per-capita basis, the petroleum reserves in China represented just 4.3% of the world average in 2000. As China becomes more mobile, the transportation sector's petroleum consumption poses important energy security problems. In addition, the rapid increase in greenhouse gas (GHG) emissions from the transport energy use creates big challenges for China, the largest carbon emitter in the world as of 2007, in working to mitigate climate change risk. Finally the air pollution impacts in many Chinese Cities is also effected by transportation modes and policies.

The Chinese government has recognized the challenge in the transport sector and committed to make changes mainly through introducing alternative fuels and regulating vehicle fuel economy. For example, since 2002, China has been promoting E10 (10% bio ethanol and 90% gasoline blend by volume) as an alternative transport fuel. As a result China is now the third largest fuel-ethanol producer in the world. In addition, China has adopted the Euro-4 tailpipe emissions standard in major cities to restrict exhaust emissions of new vehicles sold in the market. More recently, the Chinese government and the private sector have emphasized electric car technology development.

Unfortunately, recent empirical studies in Chinese cities suggest that gains in vehicle technology or fuel improvements have been overwhelmed by underlying changes in travel behavior and life-style, leading to rapid overall increases in energy use and GHG emissions as shown in Figure 1.21. China is currently the world's largest automobile market, and the vehicle fleet population is projected to grow by some 230 million between 2006 and 2030, to reach almost 270 million. While the alternative fuel and vehicle economy efforts are necessary and important given that so much of the vehicle fleet is “yet to come”, the relatively slow turn-over of the vehicle fleet and ever-changing technology may significantly delay the incorporation of a large amount of “greener” cars operating on China’s roads.

In the face of similar situations in other countries, an emerging consensus among international scholars is that a single technological fix will not resolve the complex transportation energy use and greenhouse gas (GHG) problem; efforts from the urban design and land use fields are warranted. The objective of reducing transportation energy or GHG emissions “can be viewed as a three-legged stool, with one leg related to vehicle fuel efficiency, a second to the carbon content of the fuel itself, and a third to the amount of driving or vehicle miles traveled (VMT).” Those authors further note, in the U.S. context, that relevant policy initiatives “have pinned their hopes almost exclusively on shoring up the first two legs of the stool, through the development of more efficient vehicles (such as hybrid cars) and lower-carbon fuels (such as biodiesel fuel)”. Unfortunately “a stool cannot stand on only two legs”.

A somewhat similar situation seems to exist in China, where the energy and climate initiatives in the transport sector have primarily been supply-oriented. Thus, to balance the approach, an increasing focus must explicitly target the demand side, or the third leg of the stool, to manage transportation energy use and pollution. Perhaps most important, growing problems of congestion cannot be addressed with auto efficiency and alternate fuels; it must be confronted by land-use policy, transit investments, and more intelligent street network configurations.

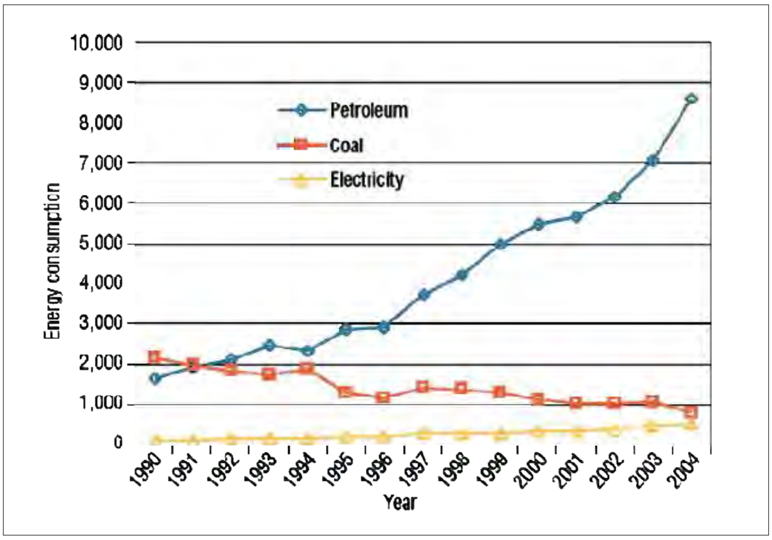


Figure 1.21: Transportation Energy Consumption Trends in China (1990 – 2004)

Empirical Land Use / Transportation Studies in Jinan

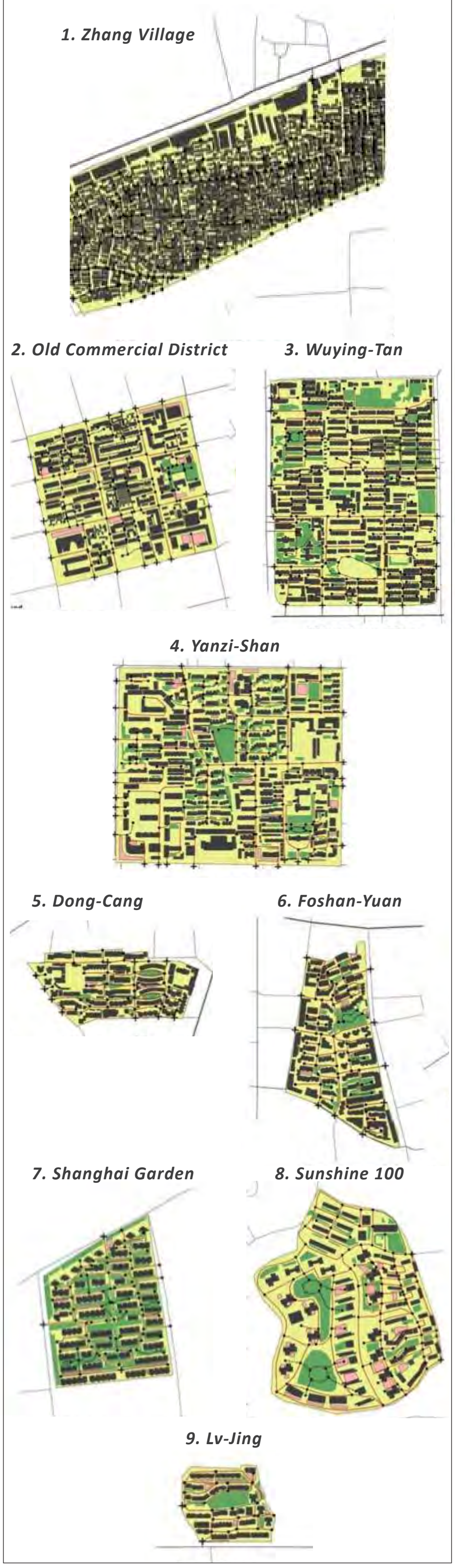
The design principles just described are not entirely innovative ideas for China; in fact, they are common features of urban forms built prior to the "superblock" era in the country, and could even date back to traditional Chinese planning practice. The legacy of these older urban forms is still prominent in most Chinese cities today, not only contributing to the diversity of cityscape but also providing a possibility to explore impacts of urban form on household travel behavior and transportation energy use.

Starting from summer 2009, an empirical study was carried out in Jinan, focusing on nine neighborhoods which represent four different urban form typologies commonly found in Chinese cities: "traditional", "grid", "enclave", and "superblock". Respectively, they represent characteristics of the local city development during different historic periods in a rough time sequence. A summary of the nine neighborhood cases and their form features associated with each typology is shown in Table 1.1.

Table 1.1: Summary of Form Features across four main Neighborhood Typologies (below) and nine Neighborhood Cases (at right).
Source: Massachusetts Institute of Technology & Tsinghua University. Making the Clean Energy City in China, Year 1 Project Report (Sponsored by Energy Foundation China) [R]. 2010

TYPOLOGY	**Traditional** *(before 1920s)*	**Grid** *(1920-30s)*	**Enclave** *(1980-90s)*	**Superblocks** *(-2000s)*
BUILDING/ STREET/ FUNCTION	1-3 story courtyards; fractal /dendritic fabric off a main shopping street, on-site employment	Block structure with different building forms contained within each block, retail on connecting streets	Linear mid-rise walk-ups; housing integrated with communal facilities (kindergartens, clinic, restaurants, convenience shops, sports facilities, etc.)	Towers in park with homogeneous residential use
ACCESS/ PARKING	No cars	Easy access; cars on-street; some parking lots	Moderately gated (walls, fences and sometimes security guards at entries); Scarce on-courts parking lots	Completely gated; sufficient parking lots (underground, surface, etc.)
NEIGHBORHOOD CASES	1. Zhang-Village	2. Old Commercial District	3. Wuying-Tan 4. Yanzi-Shan 5. Dong-Cang 6. Foshan-Yuan	7. Shanghai-Garden 8. Sunshine 100 9. Lv-Jing

NEIGHBORHOOD CASES



Following a household survey, disaggregate household transport energy uses are derived from self-reported household weekly travel diaries. Descriptive analysis reveals that the ‘superblock’ is associated with the highest per the household transportation energy use, two to five times as high as that with other neighborhood forms (Figure 1.22). The gap between the ‘superblock’ and others results from much higher energy use by car. Income also makes a difference, but does not negate the impact of the neighborhood typology on transportation energy use; each income group reveals the same marked difference in transportation energy consumption between superblocks and all the other development types (Figure 1.23).

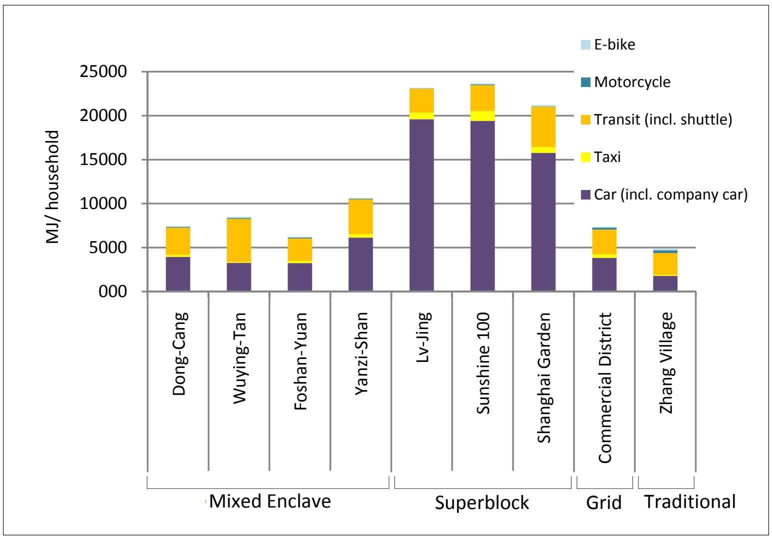


Figure 1.22: Average household annual transportation energy consumption by development type.

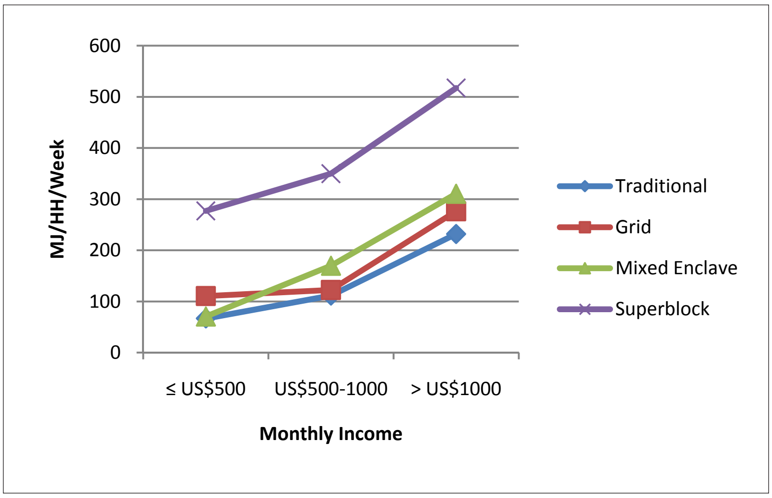


Figure 1.23: Comparison of household weekly transportation energy consumption by income

In parallel, weekly travel distances show large differences. Households in the “superblock” travel 250 km per week on average, whereas households in the other three types travel much shorter distances (150 - 170 km). As seen in Figure 1.24, the difference comes mostly from car travel distances, not distances by other modes. In addition, the composition of travel distance by mode is somewhat unique for the “traditional” typology, where households use less transit and very little car compared to others; instead, they travel more with E-bikes and less distance overall.

In comparing the mode share, there is also a large difference in car use between the “superblock” and the others. In the “superblock”, among all weekly trips, about 33% of trips are made by car, whereas the shares in other neighborhood types are lower than 8% (Figure 1.24). Regarding walk trips, the shares in the “traditional” and “enclave” exceed 40%, much higher than walk shares in the “grid” as well as the “superblock” (25 - 27%). However, the lower walk shares in the “grid” and the “superblock” have different explanations. In the “grid”, the lower share of walk trips is supplemented with trips by bike and E-bike, whereas in the “superblock”, the gap is filled almost entirely by a much higher share of car trips.

In summary, empirical analysis in the Jinan study confirms that “superblock” households consume more transportation energy than those living in other neighborhood types, as they tend to travel longer distance and more likely by car. To help chart a more energy-efficient Chinese urban future, above analysis suggests neighborhood forms in China should move towards the Low Carbon Design Principles including small blocks, mixed-use, pedestrian and bike friendly design, transit convenience and restriction of parking supply. At the city scale, it is recommended to provide ubiquitously good regional accessibility by shaping a poly-centric city structure matched with a robust transit network.

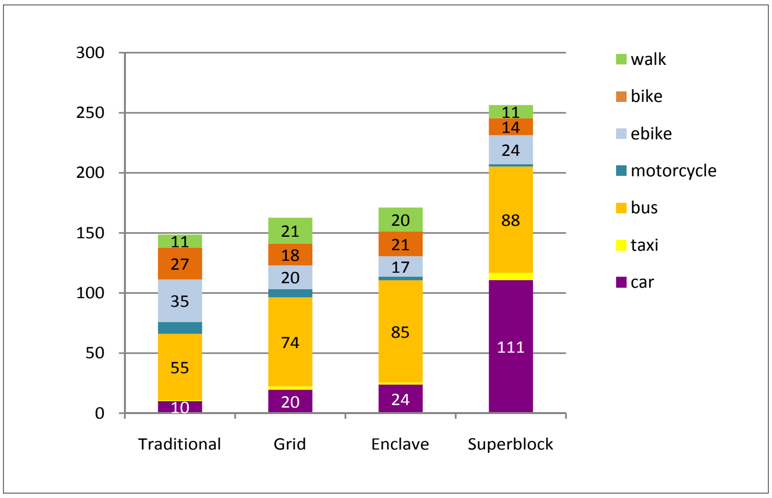


Figure 1.24: Average household weekly Travel Distance (km) across the four Neighborhood Typologies

II LAND USE AND URBAN DESIGN

INTRODUCTION

In order to develop a more sustainable city pattern built from more walkable and transit oriented districts, a new land-use and urban design approach is needed as well as new circulation networks. Rather than a system of single land-use designations placed in a superblock network, two new levels of zoning need to be established. First, at the Master Plan level, areas suitable for mixed-use, walkable districts called Transit Oriented Districts (TODs) are identified. These TOD will have a more walkable, bikeable, and transit oriented street and circulation system, called the Urban Network. They will also have a minimum mix and density of population and jobs. Within these districts some areas close to major transit stations have higher densities and land use standards in order to reinforce the investment in transit infrastructure. There are three types of potential 'Centers' within a TOD, each with land-use mixes and intensities dependent on the capacity of transit service.

At the Regulatory Plan level the TOD would be redesigned employing a more walkable street network and a land-use system of 'Small Blocks' that establish urban design standards at the block level rather than large parcel or superblock.

TOD zoning at the Master Plan level will establish a minimum intensity standard for jobs and housing for the district on a gross land area basis. The exact mix and placement of employment uses, building types, and residential development is left to the Regulatory Plan with its more specific 'Small Blocks' zoning. The 'Small Blocks' zoning proposed here includes all the typical development standards (such as FAR, site coverage etc.) but also includes urban design standards that insure a more walkable, vital development pattern.

This new zoning system is built upon the underlying city vision, infrastructure strategies and environmental analysis existing in the city's Master Plan. For example, a correlation between job centers and major transit investments is assumed to be part of the Master Plan. However the re-zoning for TOD may result in a modification of the scale and distribution of job centers, moving toward a more decentralized land-use pattern that will put less stress on the transit and auto network. Likewise the Master Plan's placement of industry, light manufacturing, warehousing and major institutions will not change as the new TODs do not include these types of uses. Finally the environmental preservation areas, key agricultural assets, and open space systems will not change as their criteria and standards remain constant.

The following two sections give detailed step-by-step methods and standards for modifying both the city's Master Plan and the more detailed Regulatory Plans within it. These two endeavors are interdependent and must be developed sequentially. The Master Plan first must be modified to identify potential TODs while the Regulatory Plans for these districts can be updated over time depending on the phasing of improvements in their various areas.

TOD DEFINITIONS AND STANDARDS

Within any City Master Plan, key areas that meet certain thresholds should be rezoned and redesigned to be more pedestrian friendly and transit oriented are designated 'TODs'. Most Master Plans already have a land-use and transportation network configured for new growth areas. The land-use is based on the standard land-use types used throughout the country described in the 1991 National Standards for Land-use Classifications. Likewise, the primary street network used in the Master Plan is well known, built from a traditional hierarchy of Expressway, Arterials, and Secondary Arterials. In addition a regional transit system is typically defined.

Using these pre-existing plan elements, identifying and redesigning key areas within the existing Master Plan framework is straightforward and should be consistent with the underlying assumptions and policy decisions of the Master Plan. The process involves two steps; first designating and mapping potential TODs and second zoning these areas with one of three mixed-use place types that are tied to the level of regional transit service and adding a more pedestrian friendly street network.

Areas of existing development with no plan for redevelopment are not appropriate for TOD designations. Existing street configurations and buildings may or may not create urban environments with the same attributes as a TOD but converting such areas cannot be undertaken unless significant redevelopment is planned.

In areas slated for redevelopment a TOD can be applied if it meets the criteria listed below. Unlike new development areas these 'Redevelopment TODs' will have additional constraints of elements that must be preserved because of historic significance, social importance, or simply that replacement is not cost effective. Given such constraints Redevelopment TODs are possible but challenging in their complexity, phasing, and economics. However the results can be very successful -- rich in identity and unique in design quality. They ultimately are a very important, though more difficult, application of the principles and practices advocated in this manual.

Redevelopment areas, sections of planned New towns, and standard new growth areas that are primarily comprised of residential and higher density commercial uses can be zoned as potential TODs. If they are served by high capacity regional transit networks and meet the land-use criteria, they should be zoned for TODs.

TOD Land-Use Criteria: Generally mid to high density residential, commercial, office, services, and retail. This includes all R and C uses and any adjacent uses. It must exclude M, W, T, U, G, D and E uses.

TOD Transit Criteria: Minimum of BRT level trunk-line transit service and/or at least one metro station. It is typical that a TOD will have a regional transit line and several sub regional feeder transit systems.

TOD Distance Criteria: Land within 800 meters of a major transit stop or station. Areas over 800 meters may be included in order to consolidate consistent land uses not isolated by major roads or open space areas.

TOD Boundary Criteria: Having met the other criteria, the extent of a new TOD will continue to the following boundaries: open space and natural features that create a significant edge; a change in land-use to a nonpedestrian orientated use; an expressway or major arterial.

TOD Required Density: Minimum of 300 people and jobs combined per gross hectare.

TOD Required Circulation System: Defined as an 'Urban Network' or equivalent (see Section III).

TOD Required Size: Minimum of 120 hectares.

TODs can vary widely in size and location. As the boundary criteria are somewhat flexible. Open space elements can be used to define the edge of a TOD or can run through its center. Typically open space elements that are too large or difficult to walk through are set to the edge, but there is no absolute rule. Also a major arterial may be an edge or, if it is replaced with a more pedestrian friendly street section such as a couplet, it can be incorporated within the TOD.

In addition, a TOD may have many transit stations each with its own appropriate density and mix. Occasionally a single station will define a TOD but only if the required boundary conditions divide it from other stations. Finally the TOD boundary designation can depend on infrastructure and development phasing, with two TODs side by side only separated by a development timeline. Figure 2.1 illustrates the progression of a typical City Master Plan area into TODs. Once these areas are zoned as a TOD, more detailed Regulatory Plans can be developed for each.

Once the TOD area is designated it must be designed to achieve two basic standards, a minimum density of jobs and housing that is higher than the city norm, and a circulation network that enhances pedestrian, bike and transit use. The logic is simple; areas that have high levels of transit investment and are mixed-use should increase density to reinforce local services and transit. Additionally, they should have a street network that allows a more pedestrian friendly environment. Major high-density job centers should be located within TODs adjacent to transit stations in order to reinforce transit for daily commute trips.

Within these new TODs the location and type of regional transit facilities becomes key to the next level of zoning. The concept is that areas closest to major transit stations should increase in density and, in the case of multiple regional lines converging, should be planed as sub-regional employment hubs. Areas within 400 - 600 meters of a significant station should be zoned in relation to the capacity of the transit system; the higher the capacity the higher the density and mix of services. Within the TOD and directly adjacent to station areas, there are three types of Centers varying in density and mix. Each is defined by its intensity of transit service: Commercial Centers, Urban Centers and Town Centers.

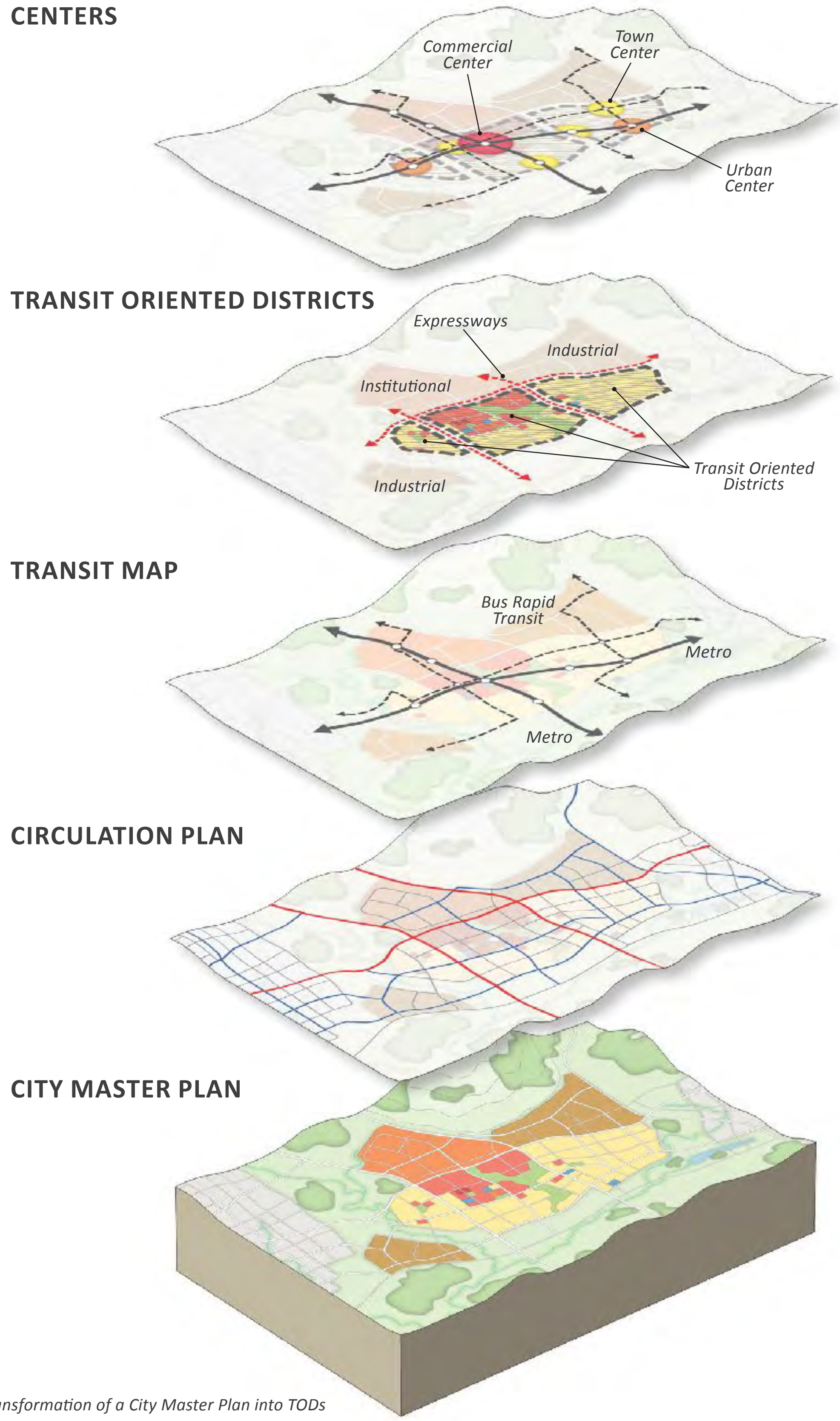


Figure 2.1: Transformation of a City Master Plan into TODs

THREE TYPES OF TOD CENTERS

Commercial Centers create a mixed-use, high density, and are primarily oriented as a regional job center. They are associated with the intersection of two regional transit lines or more.

Urban Centers develop a more balanced mix of both commercial and residential at a high density. They are located within walking distance of a regional station that serves as a transfer point for several feeder transit lines.

Town Centers are primarily medium density housing but will include a complete range of services. They are located at a single regional transit station.

Commercial Centers are located in areas with the highest level of transit service (such as the crossing of two metro lines or a major BRT hub of several lines). They are dominated by high-density office and commercial buildings, but remain mixed-use by including high density residential along with shops, parks and other services. Commercial Centers can function as a small, decentralized Central Business Districts. Because they are distributed along a transit line in multiple locations they avoid the problems of singular concentrated job centers with their peak hour commute pressures. Commutes into Commercial Centers are well served by transit as the direction of travel varies and a better jobs/housing balance is established over several close-by stations. On average, decentralizing jobs around transit stations in this manner reduces commute lengths and allows a greater mode split to transit and walking.

Urban Centers are similar but less intensive. Their overall density is less and the proportion of office buildings lower in relation to housing. The retail and commercial services are larger than the local residential population would need, and tend to serve a sub-regional market bigger than their immediate area. They are located at regional transit stations but have fewer lines and lower overall transit capacities. Typically a single metro stop with several feeder bus, streetcar or light rail lines converging will focus an Urban Center.

Finally a Town Center has the lowest densities and no significant office and employment development – it is not a commute destination. They are mixed-use and walkable residential neighborhoods that have local serving commercial and retail uses to compliment local residential needs only. Parks, schools, and other civic services are key to creating complete communities that allow people to walk or bike to most non-job related destinations. They are located with good transit access but may be served by local buses that tie them quickly to regional transit service.

COMMERCIAL CENTER

Definition:

The highest-density commercial area with mixed-use that acts as regional employment, retail and civic/ cultural hub; with a variety of high-density housing.

Location Criteria:

Located within 600 meters of the intersection of at least two metro transit stops or a major BRT Hub.

Minimum Density/Use Criteria:

Employment density (Jobs/Ha gross) = 500
Population density (Pop/Ha gross) = 200

Minimum Land Allocation (Percentage):

Parks: 10%
Civic: 5%

Figure 2.2a: Typical massing - Commercial Center

URBAN CENTER

Definition:

A high-density mixed-use district that acts as sub-regional employment, retail and civic/ cultural center; with a variety of high and mid-density housing.

Location Criteria:

Located within 400 meters of a regional transit station that is a hub for several local transit lines.

Minimum Density/Use Criteria:

Employment density (Jobs/Ha gross) =300
Population density (Pop/Ha gross) = 200

Minimum Land Allocation (Percentage):

Parks: 10%
Civic: 5%

Figure 2.2b: Typical massing - Urban Center

TOWN CENTER

Definition:

A high density housing area with retail, civic and open space amenities. Mix of high and mid-rise buildings.

Location Criteria:

Served by a single regional transit station

Minimum Density/Use Criteria:

Employment density (Jobs/Ha gross) =50
Population density (Pop/Ha gross) = 300

Minimum Land Allocation (Percentage):

Parks: 10%
Civic: 5%

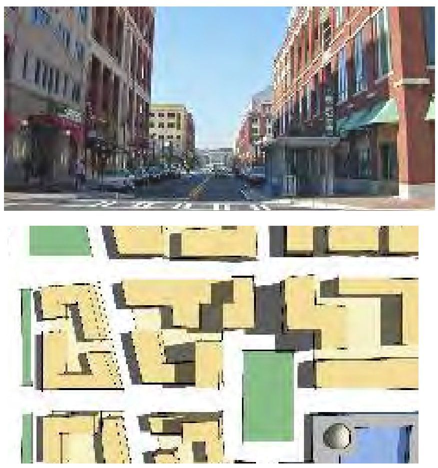
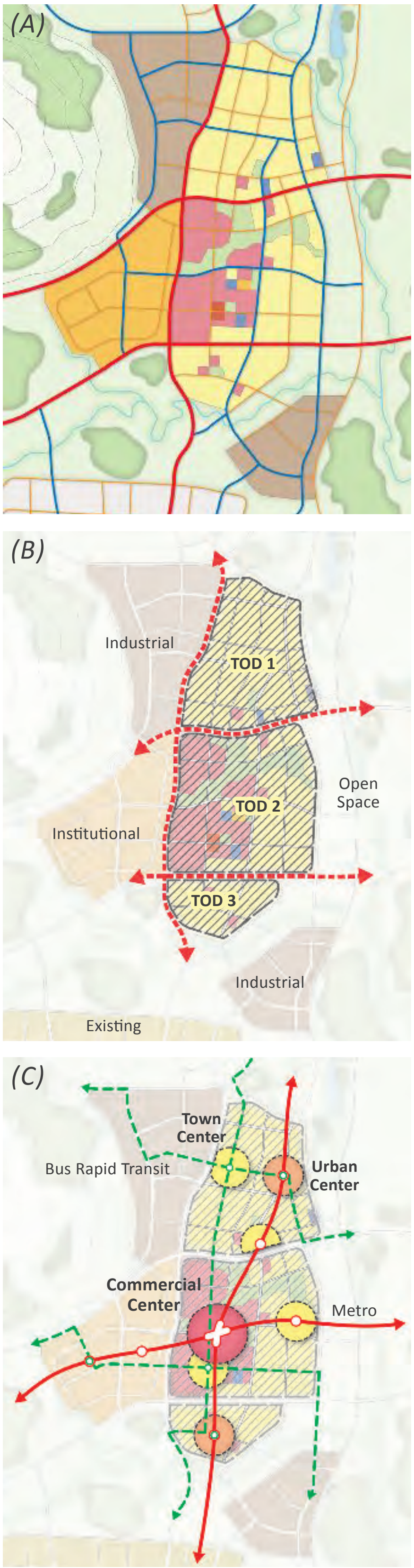


Figure 2.2c: Typical massing - Town Center



The areas outside of these Centers but within the TOD area are typically dominated by medium density residential development and all of its complimentary uses and services -- shops, schools, parks, and civic centers. The complete TOD must achieve a minimum overall density that is higher than the overall city average. The Centers have higher minimum densities and mixes of commercial development so the areas outside the Centers may be less than the overall target. The sum of the development within the Centers and the rest of the TOD must meet the minimum density of population and jobs.

A Master Plan that overlays appropriate areas with the new TOD zoning offers several advantages for a growing metropolis. Foremost it creates areas in which transit, walking and biking becomes a convenient and safe alternate to auto use. In so doing it can reduce congestion, energy use, household expense, and carbon emissions.

In addition it will create a logical and balanced distribution of jobs that are appropriately decentralized along transit corridors. Avoiding the congestion and air quality impacts of the one-directional commuting patterns associated with large CBDs is a major functional and environmental advantage of TOD development patterns. Jobs and housing are more balanced in each TOD allowing more walking and biking to work. In addition, commuter transit trips become shorter and multi-directional when jobs and housing are decentralized and balanced over several TODs. Overloaded peak hour trips are moderated and the overall transit system becomes more efficient. Vehicle traffic is also mitigated as trips are shorter, bi-directional, and reduced in the peak hour as the alternates of walking, biking and transit become more competitive and timely.

TODs also have an additional benefit of creating vital urban environments that often leverage social capital. Cities create economic activity through proximity and the social networks that evolve in mixed-use areas. There is much research and evidence of the positive economic impacts of industry clusters and mixed-use urban environments. Finally walkable residential TOD areas are more livable and less costly for households. Time and expense lost to auto use is mitigated and the social benefits of lively streets and strong local communities are well documented throughout the world.

The following maps (Figures 2.3 and 2.4) demonstrate the conversion of a typical City Master Plan into a series of TODs with transit related Centers. Figure 2.4 uses a site which is an approximation of the new town plan of Chenggong for 1.5 million population just outside of Kunming (see Part IV: 'Case Studies' for additional detail).

Figure 2.3: Existing City Master Plan (A) transformed into TODs (B) and Transit Centers (C) allocated on the basis of transit service and capacity.

Figure 2.4a: Existing New Town Master Plan for Chenggong New Town, Kunming region

Figure 2.4b: The Master Plan is then zoned into Transit Oriented Districts as defined by appropriate land use and transit services

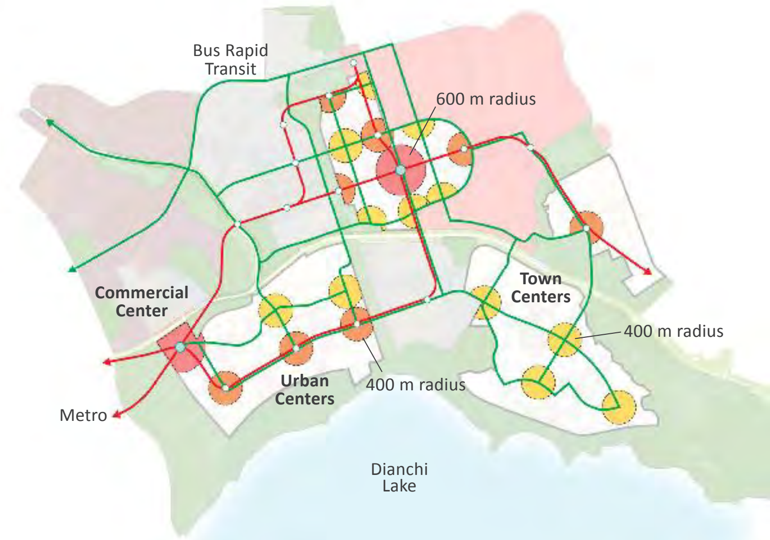


Figure 2.4c: Within each TOD Commercial, Urban, and Town Type Transit Centers

REGULATORY PLAN MODIFICATIONS

Once the City Master Plan is revised to locate and designate TOD areas and its Centers, a more detailed Regulatory Plan can be developed for each TOD. This Regulatory Plan will first develop a new more fine-grained street network as described in Part III. Once this 'Urban Network' circulation pattern is established, zoning is developed at the small block level rather than the typical superblock. The selection and placement of the new zoning must achieve the minimum densities for the various Centers within the TOD and result in an overall density of at least 300 persons and jobs overall. Figure 2.5 illustrates the step-by-step process.

As a TOD area is redesigned, the street network becomes more grid-like and the block size is reduced significantly. In this context a range of mixed-use 'small blocks' replaces the standard single-use zoning currently typical throughout China. Each 'small block' allows a range of uses and provides both normative land-use zoning regulations as well as a set of urban design standards. This new zoning system allows a more varied and mixed land-use pattern to evolve at a more human scale.

The 'small block' zoning described here typically allows a greater land-use mix in a smaller area. The standards also provide unique urban design standards that focus on creating lively and walkable street frontages which are typically missing from most zoning codes in China. The massing standards within this code respect the solar access metrics typical in China while creating a more varied skyline. Building heights naturally change more frequently with orientation and placement when developed on a small block. Each block in this urban system has a central courtyard, secure in residential blocks and public in commercial blocks. This courtyard pattern recalls the historic city forms throughout China from the Hutong to the Palace. It emerges here at a different scale, but provides the same urban layering, from public street to semi-public courtyard, to private home.

In residential areas small blocks have several advantages over the superblock. First, the social scale is more convivial. The typical small block of 1 - 1.5 ha has just 300-500 dwellings that would house at most 1,500 people; small enough for most people to recognize one another and establish strong social connections. In contrast,

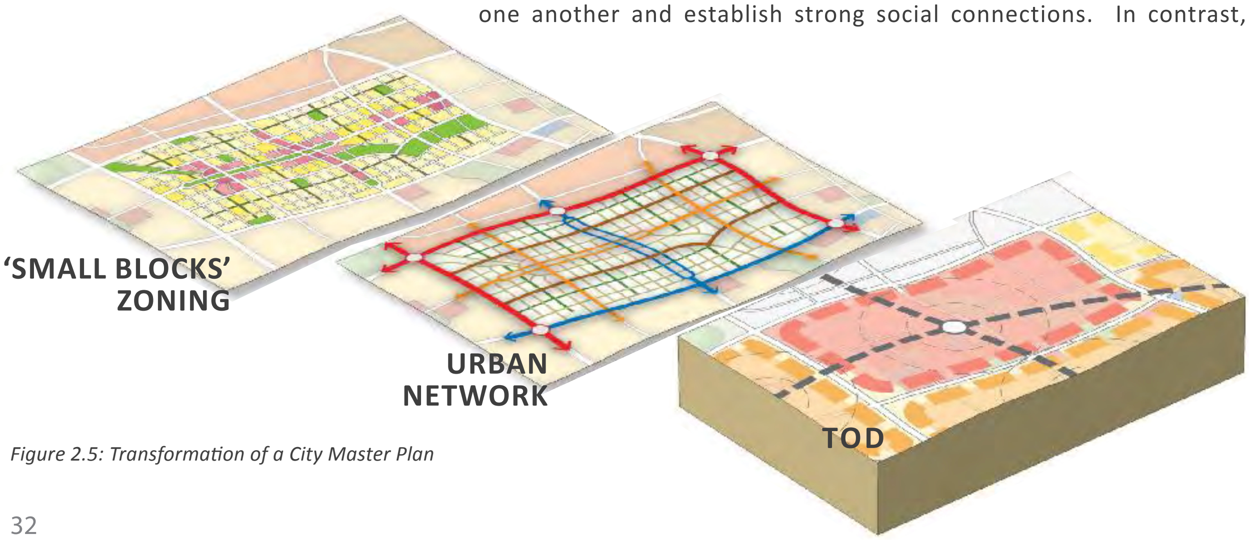


Figure 2.5: Transformation of a City Master Plan

larger superblocks contain easily 5,000 people; a scale in which many people become anonymous and children are more frequently exposed to strangers.

A second advantage of the small block is that the common area is directly visible and accessible to all the housing units. In fact, in most cases all the units have a street view and a courtyard view along with cross ventilation. This makes the common area more visible, safer and has more of a community focus. In the superblock configurations many units are placed in parallel rows with no visual or direct connection to common open space areas.

Finally small blocks increase the opportunity for street-side shops and local services. As most buildings are sited at the perimeter of the block, the ground floor naturally provides for valuable commercial and civic opportunities that enhance the street life of the neighborhood. Therefore, few dwelling units have to be located on the ground floor, an undesirable living location for most even on the interior of a superblock. Although the traditional superblock development is eliminated, multiple small blocks can be aggregated for sale to one large developer, but only if the local street network between the blocks is maintained as a public ROW.

In this zoning system, there is a range of residential 'small blocks' and commercial 'small blocks' each varied by density and degree of mix. Most buildings in the blocks, other than simple residential slabs and towers, are a mix of either residential units over shops and commercial uses or office buildings over shops and multistory retail or institutional uses. There are some blocks that allow more mixed building types such as high-rises that combine residential or hotel uses over commercial multi-story bases. But typically the ground floor is sidewalk related shops and commercial while the upper stories are either dwelling units or office space.

The mixed-use quality of a neighborhood or district is achieved by mixing different 'small blocks' side by side. The street level shops unify the pedestrian environment while the floors above provide a balance of housing or jobs for the district. While it is possible to mix different building types (commercial and housing) within one block this tends to have the disadvantage of compromising the security and identity of the block's interior courtyard. With small blocks, such mixing is not needed to achieve a good balance within a reasonable walking area.

Using the 'small block' standards, a TOD can be easily zoned to achieve the targeted jobs/housing mix and overall density for its Centers and the overall TOD. The configuration can vary dramatically as each unique place develops a design approach suited to its site and program. For example, commercial blocks can be clustered to form a grand public space, focusing on an urban park, cultural facility, or a special shopping district. Or residential blocks can be shaped around recreational parks, schools, or civic institutions. Streets can easily evolve with special characters and identities. The 'small block' system allows infinite variety and complexity within a very simple and legible framework.

‘SMALL BLOCKS’ STANDARDS

‘Small blocks’ zoning provides a fundamentally different approach to development in China. Rather than superblocks with largely identical buildings and uses, it shows how smaller blocks can be developed with a variety of building types and uses.

Some of the significant design goals are:

1. **Mix uses and add street-side retail where possible.**

   This can reinforce the pedestrian realm with easily accessible convenience activities and local shops. Lining the street with active uses and multiple entries add life and safety to the sidewalk.

2. **Mix building scales, configurations, and heights within each block.**

   Rather than repeating one or two identical building forms over a superblock, a variety of building forms and heights adds to the identity of each place and provides more residential choices within one community.

3. **Respect southern orientation and solar access.**

   Even on small blocks the vast majority of units can and should face south and building height can be adjusted to accommodate appropriate shadow setbacks.

4. **Develop private courtyard configurations.**

   By closing all sides of the blocks with retail and/or low-rise residential buildings, a semi private courtyard develops a distinct and useful identity. Transparent but secure fences can complete the block’s perimeter.

5. **Carefully mixing high-rise and low-rise buildings can increase density.**

   Mixing building types and placing tall buildings on the south side of a block can significantly increase the development density per residential block increased from the norm. At the same time human scale is maintained through the placement of low-rise buildings.

The simple range of block types delineated below represent the basic elements of any community; a variety of residential blocks with some ground floor retail and a variety of commercial blocks dominated by office uses. Other, more specific ‘small blocks’, such as regional retail destinations, schools, and unique civic uses, can be developed using the same design approach. A broad range of TODs can easily be created by mixing these ‘small blocks’ to achieve a jobs/housing/retail balance at various overall densities.

This document gives examples of the most typical ‘small blocks’ that can be of use in most city development. Certainly there are many more typologies that can and should be developed as part of creating a unique and place-specific Regulatory Plan. Here there are a range of three densities each of residential ‘small blocks’ and commercial ‘small blocks’, along with three special-use ‘small blocks’. Each of the basic residential and commercial ‘small blocks’ allows a range of complimentary uses. In addition there is a ‘mixed-use small block’ that allows a vertical transition within a building from residential to commercial and there are two ‘special use small blocks’ to illustrate potential civic, institutional, and park blocks that are typical in an urban district.

Block size and shape can vary significantly in any Regulatory Plan but the land-use and urban design standards outlined here remain the same for such variations. The figures and specific block configurations are for illustration only – in fact the advantage of the system is that variations in block size and shape along with variations in program will create a more interesting and unique urban landscape. Within the standard controls of FAR, Site Coverage, Setbacks, Street Frontage, and Solar Spacing, a large variation of block plans and building designs are allowed. Variation in building design and massing is expected and encouraged. For example, taller buildings will typically be located on the south side of the block and shorter buildings on the north in order to avoid shading buildings in the next block. Buildings along north/south streets will not have optimal solar access so it is expected that those would be developed as low-rise buildings with more commercial space.

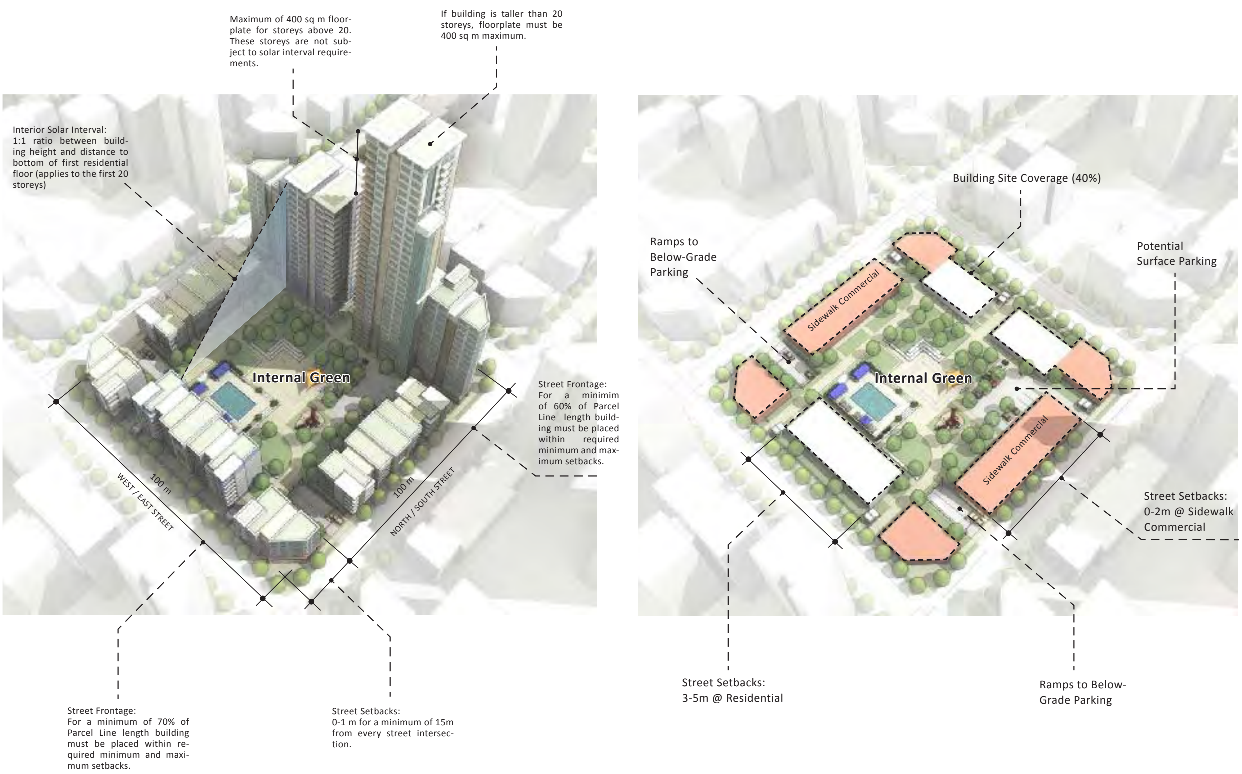
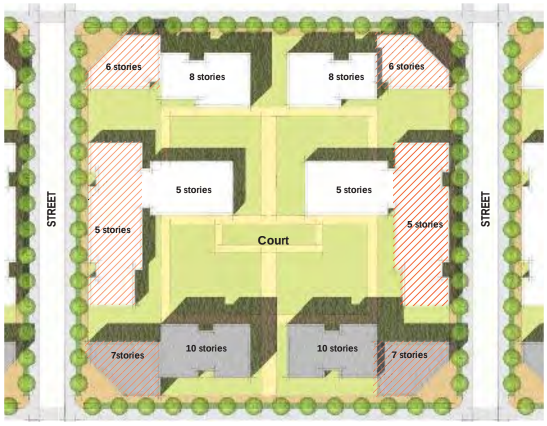
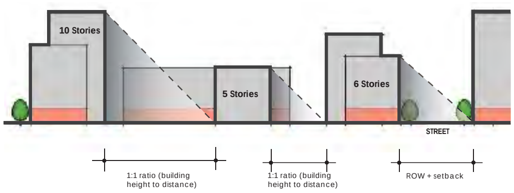


Figure 2.6: Application of Development Standards to a typical Residential Block

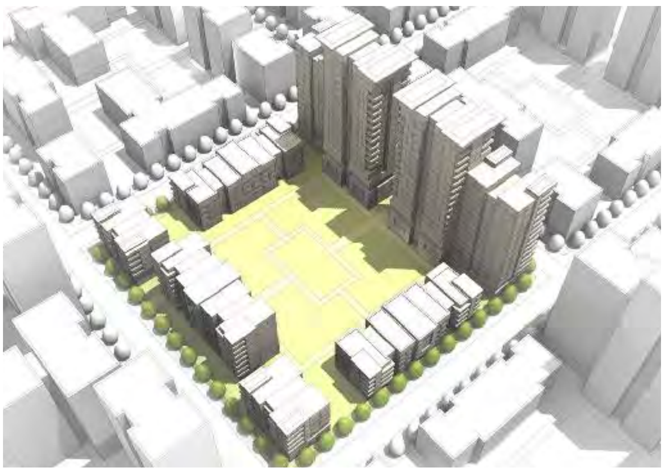
'SMALL BLOCKS' ILLUSTRATIONS

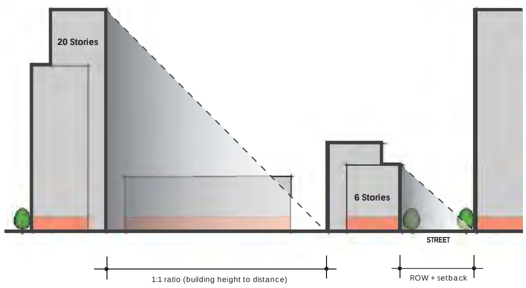
MID-RISE RESIDENTIAL	
Total Maximum FAR	2.7
Sidewalk Commercial FAR	0.12 – 0.4
Minimum Open Space	30%
Maximum Building Coverage	40%
Maximum Building Height	10 storeys



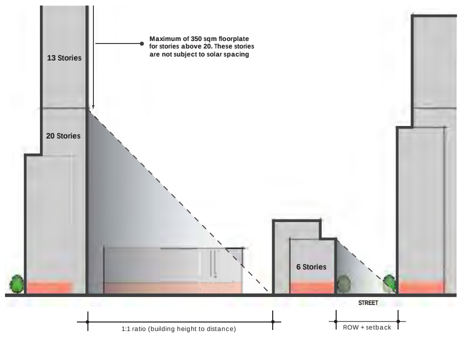


HIGH-RISE RESIDENTIAL	
Total Maximum FAR	3.5
Sidewalk Commercial FAR	0.12 – 0.4
Minimum Open Space	30%
Maximum Building Coverage	40%
Maximum Building Height	20 storeys

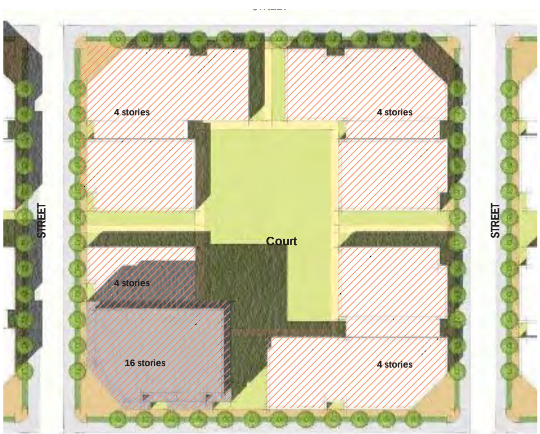


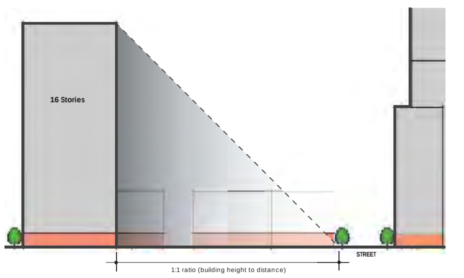


TOWER RESIDENTIAL	
Total Maximum FAR	4.0
Sidewalk Commercial FAR	0.2 – 0.4
Minimum Open Space	30%
Maximum Building Coverage	40%
Maximum Building Height	33 storeys



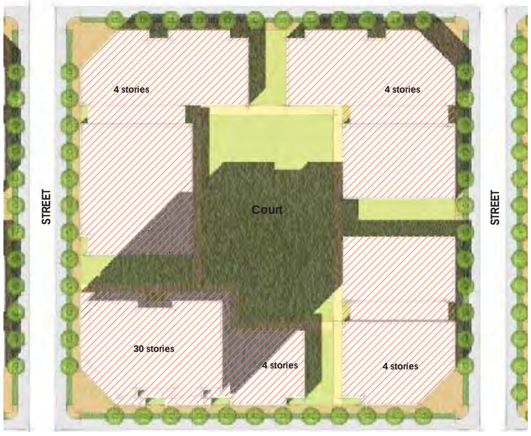
MID-RISE COMMERCIAL	
Total Maximum FAR	4.0
Sidewalk Commercial FAR	0.3 – 0.65
Minimum Open Space	20%
Maximum Building Coverage	65%
Maximum Building Height	16 storeys

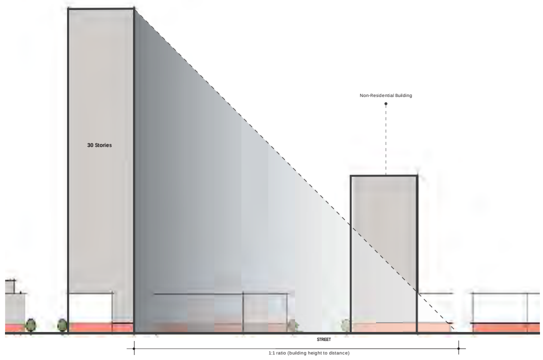




HIGH-RISE COMMERCIAL

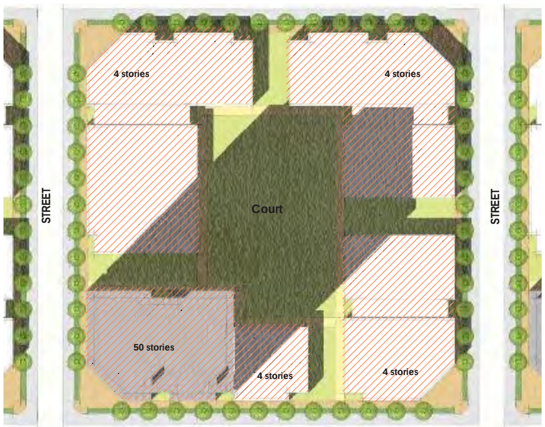
HIGH-RISE COMMERCIAL	
Total Maximum FAR	6.0
Sidewalk Commercial FAR	0.5 – 1.3
Minimum Open Space	20%
Maximum Building Coverage	65%
Maximum Building Height	30 storeys

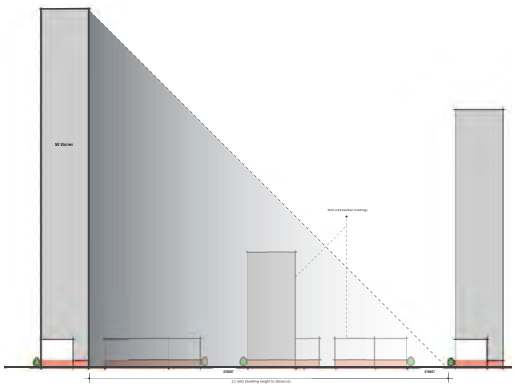




TOWER COMMERCIAL

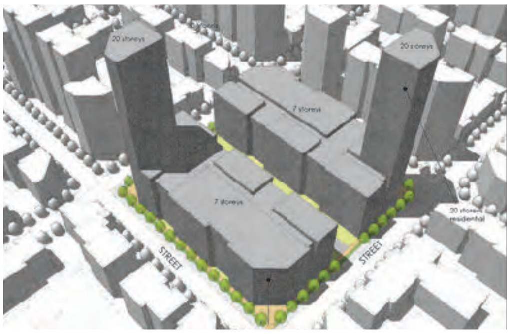
TOWER COMMERCIAL	
Total Maximum FAR	8.0
Sidewalk Commercial FAR	0.5 – 2.0
Minimum Open Space	20%
Maximum Building Coverage	65%
Maximum Building Height	50 storeys





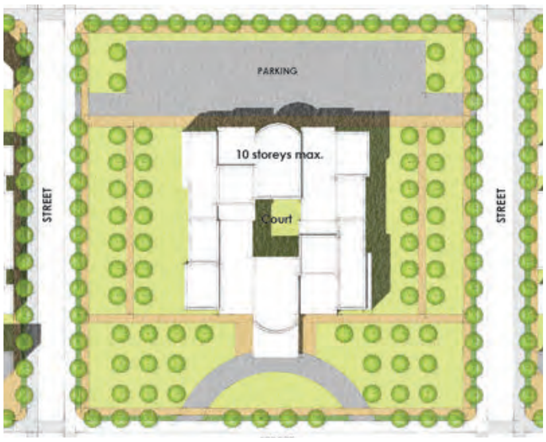
HIGH-RISE MIXED-USE

Total Maximum FAR	6.6
Sidewalk Commercial FAR	4.6
Building Coverage	80%
Maximum Building Height	27 storeys



INSTITUTIONAL

Total Maximum FAR	2.4
Sidewalk Commercial FAR	0
Building Coverage	25%
Maximum Building Height	10 storeys



PARK	
Total Maximum FAR	0.2
Sidewalk Commercial FAR	0
Building Coverage	10%
Maximum Building Height	2 storeys

URBAN DESIGN STANDARDS FOR 'SMALL BLOCKS'

Development requirements regarding urban form are incorporated into this Code as a means of implementing design criteria established in the Design Principles described earlier, ensuring a high quality of life, and minimizing the opportunity for adverse impacts on the functionality of the community. The following provides the intended purpose and definitions for each category in the Development Standards Matrix (Table 2.1).

1. **Maximum Building Height**

   Purpose: To create variation in urban form and skyline. Also to ensure that tall buildings are spaced in a way to avoid blocked views and provide solar access.

   Definition: Height is defined in the number of stories allowed, not an absolute vertical measurement. This is intended to allow height variation based on differing floor-to-floor dimensions that can be flexible without sacrificing overall FAR. It will also allow visual height variation for similar building types. The minimum height for residential floor to floor is 3 m while maximum height is 4.5 m; Minimum height for office floor to floor is 4 m while the maximum height is 6 m; minimum height for hotel floors is 3 m while the maximum is 4.5 m; minimum height for ground floor commercial is 5 m. There is a minimum building height requirement for all 'small blocks' of 3 stories. Maximum height is listed or determined by the Solar Interval, whichever is less.

2. **Total Maximum FAR**

   Purpose*:* To create variation in overall intensity of development across the site. In general higher FARs are coordinated with increased transit service.

   Definition*:* The maximum gross buildable area - not including below grade parking structures, basements, balconies, and rooftop mechanical enclosures. To calculate the maximum built up area multiply the gross parcel area by the FAR. This area is calculated to the exterior of all exterior wall enclosures and includes all interior service areas and elevator shafts. For mixed-use buildings the sum of all uses shall not exceed this FAR.

3. **Minimum/Maximum Sidewalk Commercial FAR**

   Purpose*:* To insure that streets and pedestrian areas are lined with interesting and useful ground floor uses.

   Definition*:* That segment of the total FAR allowed for sidewalk commercial use within a residential block or commercial block. These uses are used to line the ground floor of multi story buildings at significant public places such as plazas, parks, transit stops, and most streets. Other allowable ground floor uses may be civic (such as clinics, community centers, day care etc) and/or entry lobbies. The development may choose to not use the maximum sidewalk commercial FAR and this will not reduce the total FAR allotted to the parcel. The development must provide space for the minimum FAR allocation.

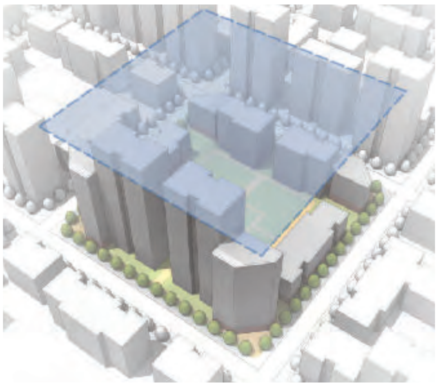


Figure 2.7a: Maximum Building Height

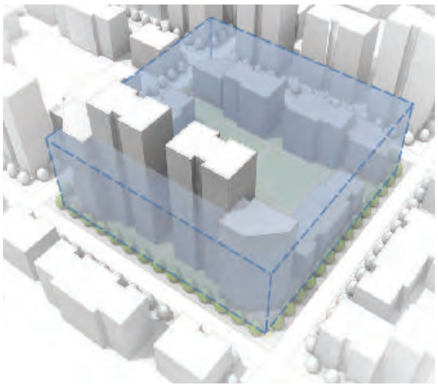


Figure 2.7b: Total maximum FAR

Figure 2.7c: Minimum/maximum Sidewalk Commercial FAR

Figure 2.7d: Building Coverage and Green Coverage

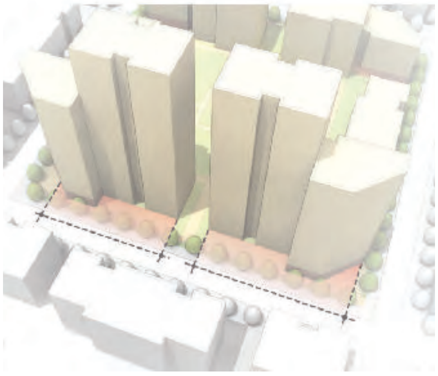


Figure 2.7e: Street Frontage

4. **Building Coverage and Green Coverage**

   ***Purpose**:* To ensure adequate open space within each block.

   ***Definition**:* Maximum Building Coverage is the proportion of the sum of all above-ground first floor area to the total parcel area. Areas not included are below-grade parking areas or basements without buildings above. The tops of such below-grade structures must be developed for community open space, landscape, recreation or circulation uses and may not be dominated by at grade parking lots. Surface parking lots may only cover 10% of the parcel; all other parking must be below grade or in parking structures. Minimum Green Coverage is the proportion of the site's landscaped or plaza open space to the total parcel area. This area includes play areas, parks, and any semi public shared space, but not driveways or surface parking.

5. **Street Frontage**

   ***Purpose**:* To ensure that each street will have building frontages that help to define the pedestrian domain and provide convenient and active uses for the pedestrian.

   ***Definition**:* Along each street or public right of way a minimum percent of the property line length is required to have buildings within the required street setback ranges. The lineal meters of building that is parallel to a street and within the setback range will be added together and divided by the total parcel frontage to calculate the percentage of street frontage. All such frontages must be occupied by a primary or secondary use and cannot be a parking structure without ground floor sidewalk commercial.

6. **Street Setbacks**

   ***Purpose**:* In order to maintain a consistent and active street edge, buildings must be placed close to the sidewalk, with setbacks based on ground floor use.

   ***Definition**:* For a building to contribute to the required street frontage it must be located within the stipulated setback range, 3-5 meters for residential uses, 1-3 meters for office uses, and 0-2 meters for sidewalk commercial. Buildings may have larger setbacks and/or be placed within the block but these will not contribute to the Frontage Requirement. It is assumed that a 5 meter setback will allow ground floor residential uses while anything less than 3 meters will have non-residential uses. The setback shall be measured from the property line.

7. **Solar Spacing**

   ***Purpose**:* To ensure solar access for a majority of residential buildings.

   ***Definition**:* For residential uses building separations will vary in proportion to the building Height in such a way as to maintain a 1:1 ratio measured perpendicular from the north façade of each building within the parcel and across public rights of way. Buildings along the northern boundary of a parcel will therefore be limited to the adjacent ROW dimension plus any setbacks. Other building heights will be limited to the distance to the next on-site building with the exception of the interval to buildings fronting North/ South streets. The interval in this case shall be no less than 10 meters. For commercial blocks with buildings over 7 stories, a 1:1 ratio must be maintained to any residential property line in adjacent blocks measured perpendicular to the north façade of the building. Towers, because of their slender profile, are not required to maintain these setbacks.

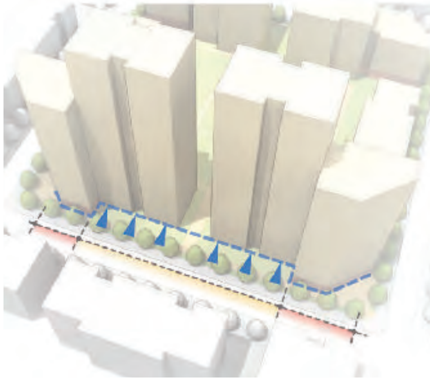


Figure 2.7f: Street Setbacks

8. Tower Maximum Floorplate

Purpose: To minimize the bulk and shadows of tall structures

Definition: For residential buildings the maximum size of the average floor over 20 stories shall be 600 square meters not including balconies. For Commercial buildings the maximum size of the average floor plate over 16 stories shall be 1200 square meters. Towers can be placed anywhere on a parcel and need not comply with the Solar Interval standards. It is preferred to locate tall buildings and their lobbies at corners.

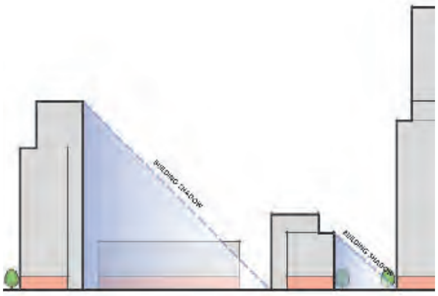


Figure 2.7g: Solar Spacing

9. Primary Pedestrian Entry

Purpose: To active the sidewalk and provide street identity for most buildings.

Definition: Although a building may have several entries, the primary entry must be located on and directly accessible to the most important public space or street that a parcel fronts. In some cases the parcel may not front a key street or public space, in which case a primary entry off a local street is allowed. Buildings located to the interior of a parcel may be accessed by a gated pedestrian path which connects directly to a sidewalk.

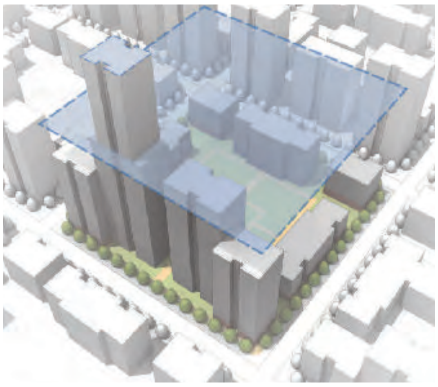


Figure 2.7h: Tower Maximum Floorplate

10. Parking Structure

Purpose: To accommodate off-street parking while providing for at-grade open space and courtyards.

Definition: Below-grade parking structures are preferred in all cases and should be used to reduce the height of any above-grade structures. Any above-grade parking structures shall be included within the site coverage and FAR limits. The required parking ratios are designed to provide adequate parking space throughout the project and also to encourage transit use for commuting to employment areas and commercial centers. Auto access to parking structures will be from one-way streets where possible and/ or from local streets. No entries are permitted off streets with rights-of-way greater than 50 m to prevent traffic congestion in major boulevards and avenues. All entries to parking structures will be kept 20 m from any intersection. Where parking structures front public streets, spaces, plazas or parks, the ground floor must be allocated to Sidewalk Commercial uses for a minimum depth of 6 m.

Table 2.1: Development Standards Matrix

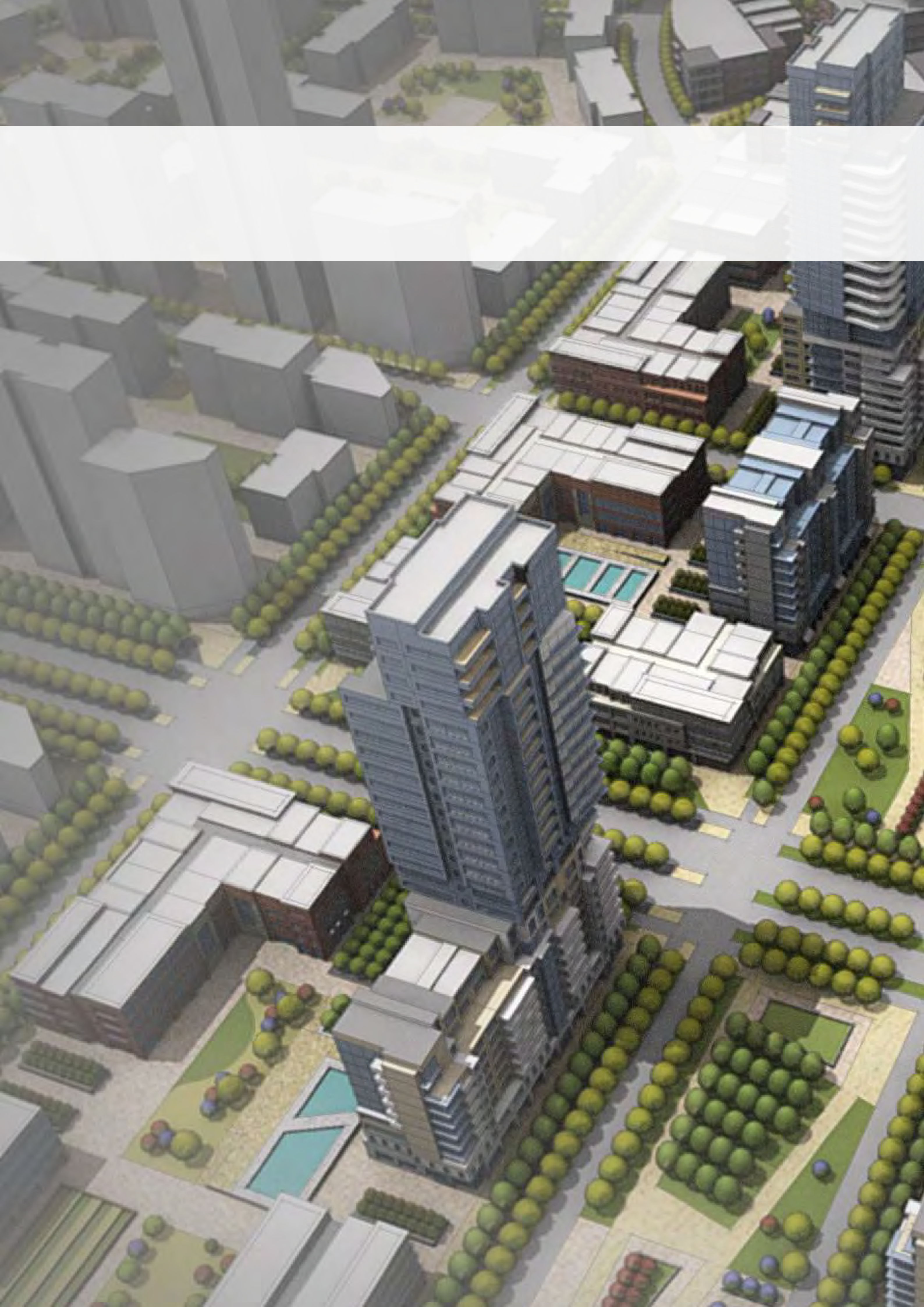
'SMALL BLOCK'	Mid Rise Residential	High Rise Residential	Tower Residential	Mid Rise Commercial	High Rise Commercial	Tower Commercial
						
1) Maximum Building Height (a)	10 storeys Max. 46m	20 storeys Max. 91m	33 storeys Max. 149m	16 storeys Max. 96m	30 storeys Max. 180m	50 storeys Max. 300m
2) Total Maximum FAR	2.7	3.5	4.0	4.0	6.0	8.0
3) Minimum/Maximum Side-walk Commercial (b) FAR	0.12 / 0.4	0.12 / 0.4	0.2 / 0.4	0.3 / 0.65	0.5 / 1.3	0.5 / 2.0
4A) Building Coverage Max.	40%	40%	40%	65%	65%	65%
4B) Green Coverage Min.	30%	30%	30%	20%	20%	20%
5) Street Frontage (c)	Min. 70% facing East/West streets Min. 60% facing North/ South streets	Min. 70% facing East/West streets Min. 60% facing North/ South streets	Min. 70% facing East/West streets Min. 60% facing North/ South streets	Min. 70% facing all streets	Min. 70% facing all streets	Min. 70% facing all streets
6) Maximum and Minimum Street Front Setbacks	0 - 2 meters @ Sidewalk Commercial. 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection	0 - 2 meters @ Sidewalk Commercial 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection	0 - 2 meters @ Sidewalk Commercial 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection	0 - 2 meters @ Sidewalk Commercial 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection	0 - 2 meters @ Sidewalk Commercial 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection	0 - 2 meters @ Sidewalk Commercial 1 - 3 meters @ Office 3 - 5 meters @ Residential 0 - 1 meter within 15 meters of intersection
7) Solar Spacing - All 'Small Blocks' (d)	North side - building height limited to adjacent street right of way dimension plus building setback Block Interior - maximum 45 degrees from building top to the bottom of the first residential floor of the building to the north (e)	North side - building height limited to adjacent street right of way dimension plus building setback Block Interior - maximum 45 degrees from building top to the bottom of the first residential floor of the building to the north (e)	North side - building height limited to adjacent street right of way dimension plus building setback Block Interior - maximum 45 degrees from building top to the bottom of the first residential floor of the building to the north (e)	Building elements 7-16 stories must be placed to provide 45 degrees solar setback to any residential property lines to the north	Building elements 7-16 stories must be placed to provide 45 degrees solar setback to any residential property lines to the north	Building elements 7-30 stories must be placed to provide 45 degrees solar setback to any residential property lines to the north
8) Tower elements Maximum Floor plate	NA	NA	400 square meters for tower element over 20 storeys	NA	1,200 square meters for tower element over 16 storeys	1,200 square meters for tower element over 16 storeys
9) Primary Pedestrian Entry	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.
10A) Parking Structure	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.
11B) Maximum Parking Ratio	1 space per dwelling unit Other uses as per existing code	1 space per dwelling unit Other uses as per existing code	1 space per dwelling unit Other uses as per existing code	0.2 spaces per employee for general office. Other uses as per existing code	0.2 spaces per employee for general office. Other uses as per existing code	0.2 spaces per employee for general office. Special uses as per existing code
12C) Parking Entry	No entry off major streets 50 meters or greater No entry within 20 meters of intersection	No entry off major streets 50 meters or greater No entry within 20 meters of intersection	No entry off major streets 50 meters or greater No entry within 20 meters of intersection	No entry off major streets 50 meters or greater No entry within 20 meters of intersection	No entry off major streets 50 meters or greater No entry within 20 meters of intersection	No entry off major streets 50 meters or greater No entry within 20 meters of intersection

LAND USE STANDARDS FOR 'SMALL BLOCKS'

Each of the 'small blocks' allows a range of complimentary uses defined using the classification system typical throughout China. There are four categories of potential use: Primary, Allowed, Not Allowed, Ground floor only, and Conditional. The Primary use can mix several use categories designated 'P'. Allowed uses 'A' can substitute for a Primary use but typically do not dominate the buildings. Conditional uses 'C' must be reviewed and approved by the local agency. Ground Floor uses 'G' or lower floor uses are allowed only on the levels specified. This is intended to reinforce street-side uses that add activity, safety, convenience and life to the sidewalk. 'Not Allowed Uses' ('N') cannot be developed on the specified 'small block'.

Table 2.2: Land Use Matrix

'SMALL BLOCK'	Mid Rise Residential	High Rise Residential	Tower Residential	Mid Rise Commercial	High Rise Commercial	Tower Commercial
						
R	Residential					
R2	P	P	P	N	N	N
C	Commercial and Public Facilites					
C1 Administrative Office	G	G+1	G+1	P	P	P
C2 Commercial and Financing	G	G+1	G+2	P	P	P
C3 Cultural and Recreational	G	G+1	G+1	P	P	P
C4 Sports	G	G+1	G+1	P	P	P
C5 Medical and Health	G	G+1	G+1	P	P	P
C6 Education and Research	G	G+1	G+1	P	P	P
C8 Other Public Facilities	G	G	G	P	P	P
M	Industrial and Manufacturing					
	N	N	N	N	N	N
W	Warehouse					
	N	N	N	N	N	N
S	Road, Street and Square					
S2 Square	N	N	N	P	P	P
S3 Parking Structure	N	N	N	C	C	C
U	Municipal Utilities					
U3 Postal Facilities	N	N	N	G	G	G
U9 Other Municipal Facilities	N	N	N	G	G	G
G	Green Space					
G1 Public Open Space	N	N	N	N	N	N
G2 Productive and Protective Green Area	N	N	N	N	N	N



III CIRCULATION SYSTEMS

INTRODUCTION

Figure 3.1: Typical traffic conditions on Chang'An Avenue, Beijing's main thoroughfare

For many cities in China, rapid growth and a steady increase in automobile ownership have become key factors resulting in increasing traffic congestion. For example, in 2010, the number of automobiles in Beijing totaled 4.5 million or one vehicle for every 4 residents and is expected to reach 5 million by end of 2010. In 2003, the total number of automobiles in Beijing was about 2 million or one vehicle for every 7.3 residents and in 1998, the total number of automobiles in Beijing was about 1.1 million or one vehicle every 11.3 residents. The increase in automobiles in this city has far exceeded the growth in residents over the last decade or so. But this phenomenon is not isolated in the capital, the numbers for a regional city like Kunming are higher; the total number of automobiles is 1.2 million, with an automobile for every 5.2 residents.

Compared to the ratios for major metropolitan areas in United States of one automobile for every two residents, vehicle ownership in Chinese cities is still low. However, the rapid growth of automobiles in China has not been adequately accommodated by the current transportation system, resulting in over-saturated roadways and extended hours of traffic congestion for commuters. According to the Beijing Transportation Operations 2009 Report, the number of "congested" roadway segments during the PM peak period increased from 581 in June 2009 to 1,081 in December 2009. The average travel speeds on the roadway system within the 5th Ring Road were reported to be 24.7 kilometers per hour (km/h) and 22.3 km/h during the AM and PM peak periods, respectively. These traffic congestion issues have adversely affected urban growth, economic development, public health, and the quality of life for residents. It is imperative that Beijing's problems not be replicated across the country.

Key solutions to relieving traffic congestion include maximizing the efficiency of the roadway network, providing safe and attractive alternatives to driving, and locating complementary land uses in close proximity to one another so as to encourage walking and bicycling. It is not a simple matter of building more transit capacity; it is a whole city design problem.

Roadway systems in quite a few Chinese cities including Beijing and Kunming feature multiple-level ring roads connected by big boulevards, which are supported by local streets. Key characteristics of this conventional arterial setting include superblocks with signalized intersections at an average spacing of 300 to 500 meters, grade-separated pedestrian/bicycle crossings at mid-block locations or at intersections, and large-scale intersections with long crosswalks for pedestrians and bicyclists.

This conventional arterial system has the following limitations in an urban setting:

- A network of wide 'canyon-like' streets creates a hostile environment for pedestrians and bicyclists. Wider streets lead to increased crossing distances, increase distances to intersections for pedestrians, higher traffic concentrations on fewer roads, few alternative routes for emergencies, and complex traffic movement at intersections that threaten pedestrian and bicycle comfort and safety.
- Drivers are inconvenienced because of more circuitous routes when mid block left turning movements are disallowed. Often with few entrances, superblocks add to the circuitous access routes for cars as well as pedestrians.
- Due to lack of parallel roadway capacity, traffic dispersal is limited and drivers are observed to use private entrances/exits as cut through. For the same reason, traffic management due to an event or accident is much more difficult with fewer alternative paths to re-route traffic.
- Increased congestion along conventional boulevards also negatively affects bus transit performance, which further discourages walking and bicycling, the primary modes of access to transit.
- Traffic capacity is sacrificed due to increased traffic levels, conflicts, complex movement sequences and lost time at intersections. Also, large two-way streets with extended spacing between intersections reduce the effectiveness of signal coordination and traffic flow efficiency along corridors.

The alternate is a more traditional city grid of streets with higher intersection density and a broader range of street types. High volumes of through-traffic would be dispersed over parallel and smaller roads or onto one-way couplets. Pedestrian and bike zones would be protected and enhanced on all streets. Transit lines and BRT systems would gain dedicated lanes and auto-free streets would enhance alternate modes.

Studies linking such urban forms with travel behavior demonstrate that major shifts in mode split and vehicle travel distances are possible. The next section outlines the results of one such study and begins to identify the critical design elements of this circulation alternative.

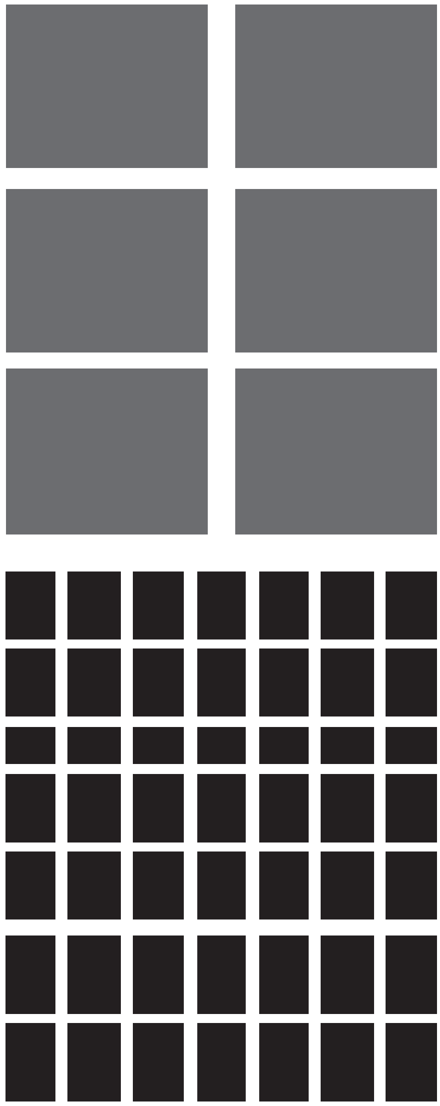


Figure 3.2: Superblock grid compared to an Urban network of smaller blocks and narrower streets.

A NEW CIRCULATION PARADIGM: THE URBAN NETWORK

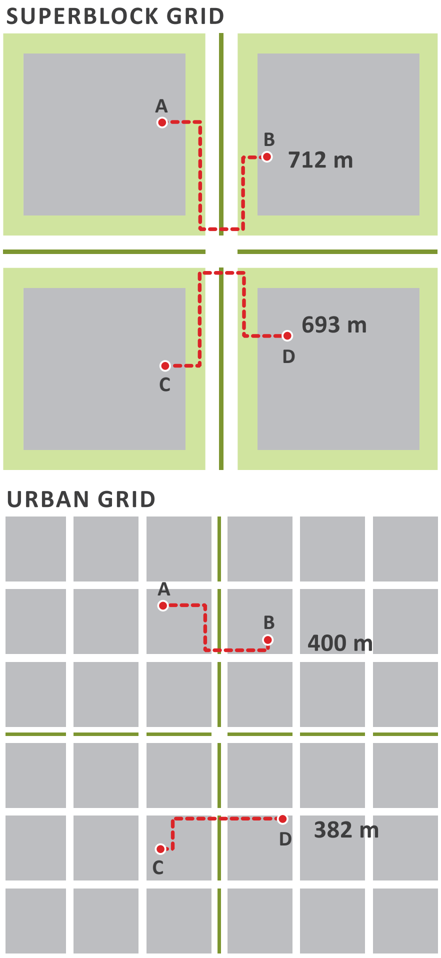


Figure 3.3: Comparison of pedestrian travel distance in a Superblock grid (500 m) and an Urban grid at the same scale - lack of street permeability, fewer pedestrian crossings and wider intersection crossing distances in a Superblock result in the pedestrian having to walk almost twice the distance to get from one point to another as compared to an Urban grid.

In order to develop more sustainable, low-carbon cities a new circulation strategy that compliments mixed-use developments is needed. Such a network will balance the needs of pedestrians, bikes, transit, cars and trucks in a system of multi-modal rights of way. Key to the system is a grid that increases the number of through roads and thereby disperses traffic. Foremost the circulation system must encourage and support alternate modes to the auto by making transit ubiquitous, walking and biking safe and convenient, and bringing destinations closer to home and transit stations. Once a reasonable mode share to autos is attained through land-use and design strategies, a more robust street grid has been shown to handle traffic more effectively than coarser arterial systems. We will call the alternate fine-grained circulation system the 'Urban Network' and the current arterial system the 'Superblock System'. It should be noted that a City Master Plan should and will employ both systems. The Urban Network is appropriate for mixed-use and dense residential and commercial districts, called TODs, while the Superblock System is appropriate for large areas of manufacturing, industrial, warehousing or institutional use. Both systems must be supported by adequate expressway, freeways, and metro level transit systems. The transition from one system to another will be described.

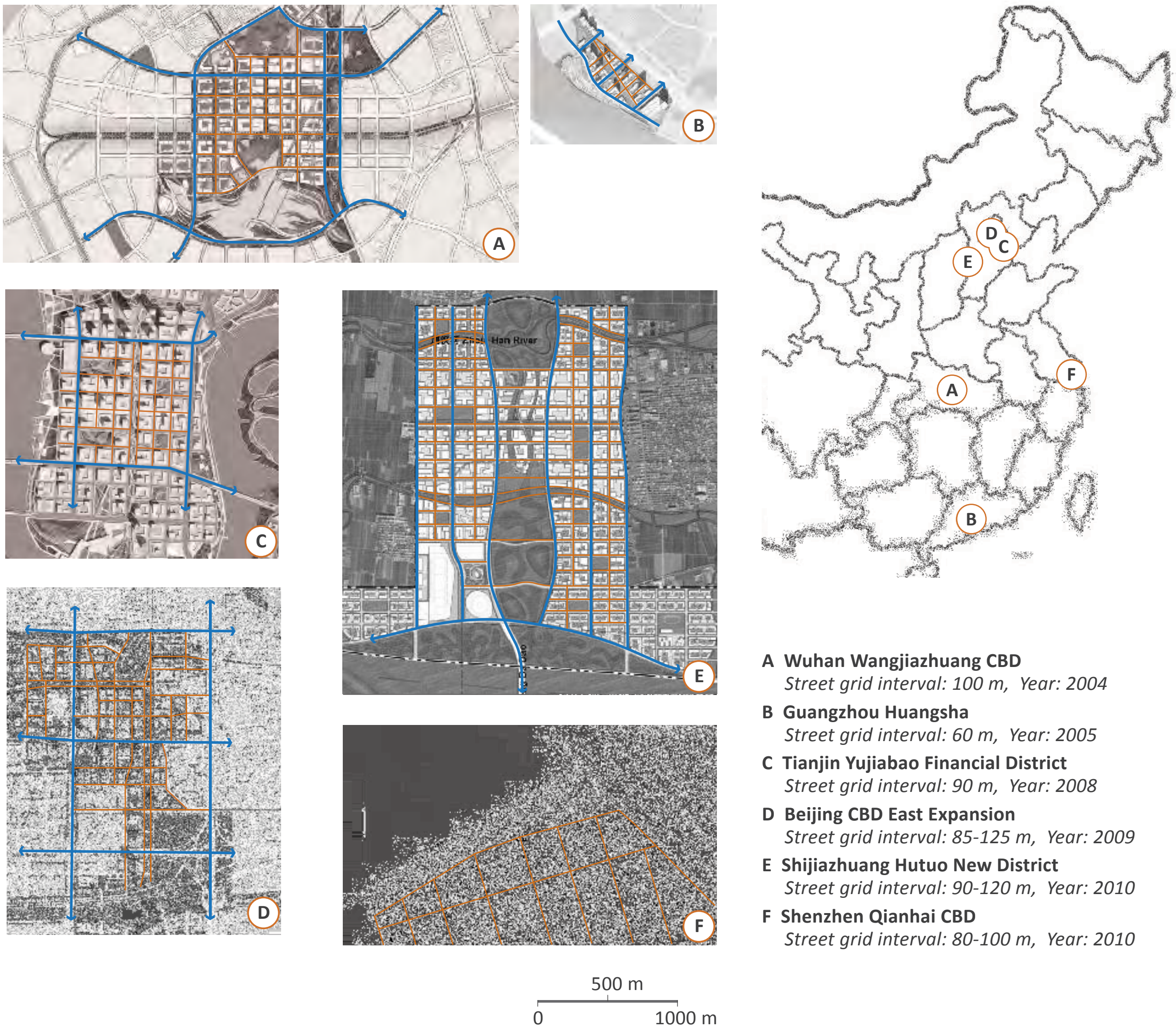
The Urban Network would be developed in the Regulatory Plan for all areas designated as Transit Oriented Districts in the City Master Plan. This network allocates space in the circulation system for all modes of travel while enhancing the opportunity to walk to close destinations and transit stops. It will provide adequate areas for bikes to move throughout a district safely while allocating dedicated lanes for transit, whether Streetcars, BRT or Light Rail. The network must disperse traffic over many smaller streets, some one-way, to allow easy and safe pedestrian crossings.

The Urban Network is built out of a range of street types and produces a relatively small block pattern. Major through traffic is handled with multiple minor arterials called Avenues of no more than 45 feet or by pairs of one-way streets called Couplets. Special Transit Boulevards would provide space for dedicated lane transit systems such as BRT lines. Auto-free streets that accommodate bikeways, pedestrian shopping areas, and dedicated transit lanes complement the through streets. Finally a network of local streets providing local access to parcels with bike lanes and generous sidewalks completes the network.

The advantages of the Urban Network are as follows:

1. The network disperses traffic over multiple routes reducing loads and pedestrian crossing dimension on most streets
2. It allows short trips more direct routes on local roads with mid block left turns into parcels
3. In case of blockage or emergency, traffic can be easily diverted to alternate routes

Figure 3.4: Grid case studies - recent projects in China have started to experiment with a finer urban grid.crossings.



A Wuhan Wangjiazhuang CBD
Street grid interval: 100 m, Year: 2004

B Guangzhou Huangsha
Street grid interval: 60 m, Year: 2005

C Tianjin Yujiabao Financial District
Street grid interval: 90 m, Year: 2008

D Beijing CBD East Expansion
Street grid interval: 85-125 m, Year: 2009

E Shijiazhuang Hutuo New District
Street grid interval: 90-120 m, Year: 2010

F Shenzhen Qianhai CBD
Street grid interval: 80-100 m, Year: 2010

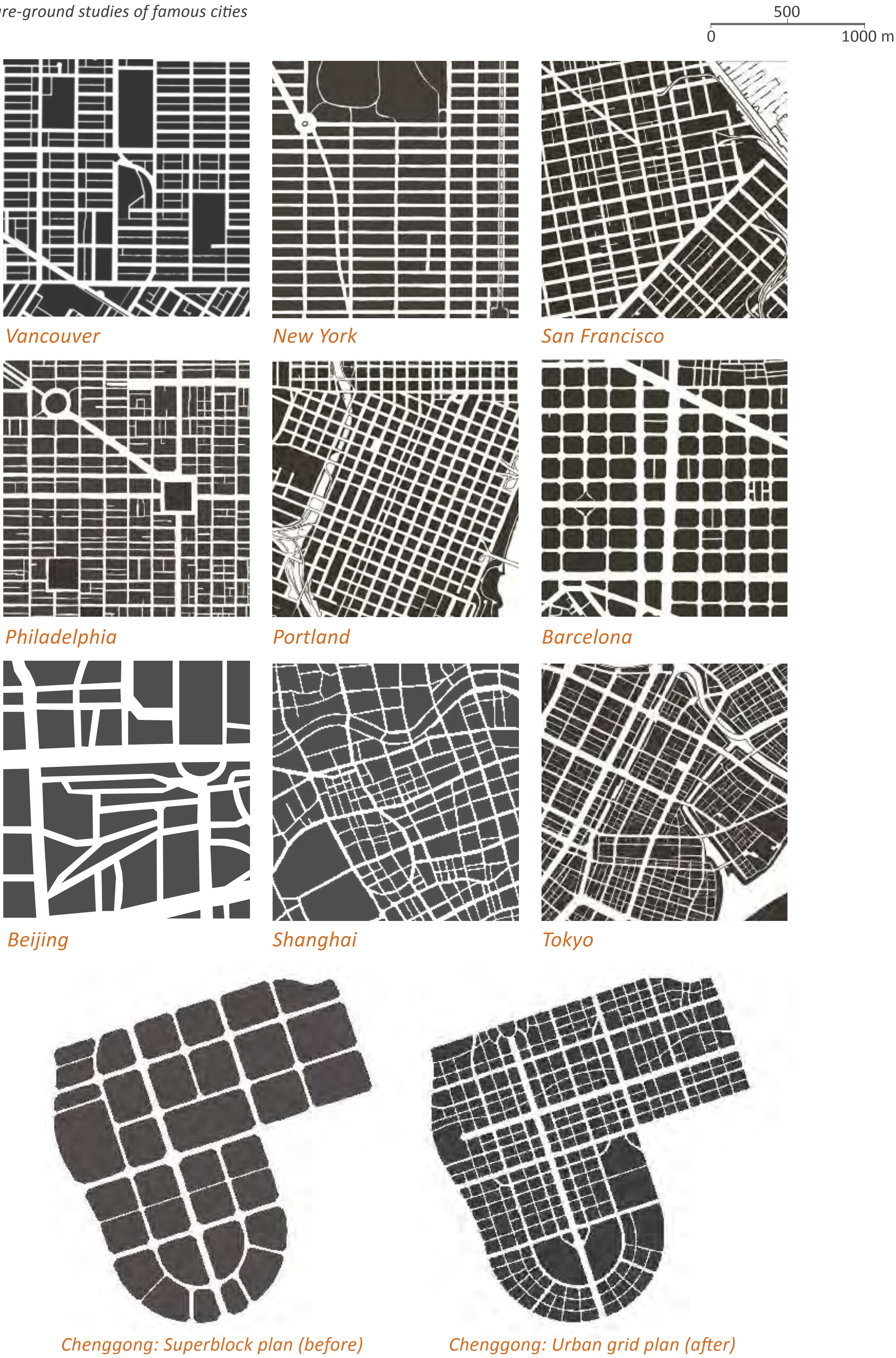
4. With more frequent intersections and shorter street crossings pedestrians have shorter, safer routes
5. Smaller street sections make transit systems are more accessible to pedestrians
6. Smaller blocks provide for more adaptable urban forms, more flexibility of use, and opportunities for smaller developers
7. Emergency vehicles have multiple means of access to any destination
8. One way couplets eliminate left turn phases allowing signal synchronization and optimal traffic ‘platooning’

Key to the Urban Network is small blocks of approximately 100-200 meters per side. The advantages for development at this scale are multiple. For residential developments each building would front a secure internal courtyard and open space as well as a public street. The quantity of housing units per block could range from approximately 200 to 700, a social scale more desirable in many ways. Ground floor shops at the perimeters are more accessible and support street life and neighborhood identity. Each block can contain a variety of building configurations dependent on solar orientation and street frontage. For example buildings on east west streets can be taller and proportioned to the spacing to the next set of buildings. Buildings on north south streets without good solar orientation can be lower with non-residential uses mixed in. Overall the development is more varied and human scaled while it allows smaller developers to participate in city building. Of course multiple blocks can be combined to accommodate larger development needs.

The Urban Network also requires narrow street sections that enhance pedestrian access. Narrower streets can be accomplished by employing multiple through streets and/or couplets. A more through explanation and analysis of couplets can be found on page 68. Narrow streets do not necessarily diminish network capacity. The strategy to maintain through traffic volumes is simple; a six lane major arterial can be diverted to two three-lane one way streets that actually have more capacity because they have the advantage of no intersection delays for left turn movements. Or the six lane arterial traffic could be accommodated by two four-lane minor arterials closely spaced. In the Urban Network system, major and secondary arterials are replaced by narrower ‘couplets’ and ‘avenues’. More detailed standards for these streets and their intersection configurations can be found on page 63.

In comparison the superblock system is relatively simple; it consists of major and secondary arterials spaced on a 300 to 500 meter grid, with lane capacities and design speed varying with demand. It has been demonstrated in many circumstances that this system cannot handle the volumes of traffic China’s high-density cities generate if alternate modes are not encouraged. Even with 8 and 10 lane arterials, the lack of alternative routes leads to problems from accidents and slow, complicated intersections. In fact, the system generates its own debilitating feedback loop; the large street sections discourages pedestrian, biking and transit mobility, which leads to more vehicle traffic and therefore wider streets. This then creates an environment even more inhospitable to alternate travel modes. Additionally, the system has other drawbacks. These networks create massive intersection configurations as the number of lanes increase to handle the concentration of through trips combining with local trips. The signals at the intersections have typically four phases or more and therefore result in slower travel times, difficult pedestrian crossing, and poor synchronization. These large intersections and slow signal phases result in an environment hostile to pedestrians and bikes while making access to transit more difficult. To compensate expensive (and more circuitous) pedestrian overcrossings are added.

Figure 3.5: Figure-ground studies of famous cities



In addition, limits on intersection spacing means that local roads are allowed only right turn in and out, often forcing short vehicle trips onto roads designed for through traffic while forcing pedestrians to walk further to find a street crossing.

The superblock system has its advantages however:

1. Through traffic is concentrated to the benefit of auto-centric businesses
2. There are reduced volumes of traffic on local streets which are often gated and within a superblock development
3. Neighborhood security is simplified at the superblock scale
4. Government construction and maintenance is eased by effectively privatizing most local streets
5. Sale of developable parcels can happen simply at a large scale
6. More adaptable to areas of severe topographic constraints

Both systems will be useful and necessary depending on context and urban design goals. This chapter will focus on the standards and practices critical for realizing the Urban Network as the Superblock System is currently understood and standardized. Realizing the Urban Network involves three sets of standards: new street sections that accommodate multimodal users at a variety of scales; network standards that delineate the mix and spacing of these new street types; and intersection designs that optimize throughput without compromising pedestrians.

The current Superblock System of Expressways, Arterials, and Secondary Arterials is typically in place at the Master Plan scale. Based on transit capacity, density, and job concentrations, new mixed-use TODs would be added into the City Master Plan. Only within these new districts (described in greater detail in Part II) would the street network be modified into a denser street grid called the 'Urban Network'. Then as part of updating the Regulatory Plan, the modification of the street network would be designed in detail to respond to the district's specific intensities of use, trip generation estimates and surrounding influences. In the designated TOD areas only, block size would be reduced as a denser, more redundant street network is developed. The next section describes the street sections, standards and methods needed in this new context-specific circulation system.

URBAN NETWORK DESIGN CRITERIA

The more human scaled street system of the Urban Network is intended only for areas in which a high degree of pedestrian and bike activity is to be encouraged. The TOD Districts and TODs described in Part III designate such areas as dense, mixed-use, and transit-oriented commercial and residential districts. Expressways, freeways, major arterials, or open space typically will define the boundaries between low pedestrian zones and these mixed-use areas.

As the street network transitions into the TOD District, block size decreases, through-street frequency increases, and the typical Right of Way (ROW) decreases. Streets have limited dimension and lane capacity to ease pedestrian crossings and disperse traffic over parallel routes.

Typically the network is designed as a hierarchy of Couplets, Transit Boulevards, Avenues, Local streets, and Auto-free streets. The Boulevards and Couplets carry the loads of the typical Major Arterials and Avenues carry the loads of Secondary Arterials. All of the street sections used in Transit Oriented Districts include enhanced zones for pedestrians, bikes and transit facilities.

The five primary street types of the Urban Network are described and illustrated below. Each street type is considered as having two zones; the street-side (non-motor) zone for pedestrians and bikes (typically 10 meters each side), and a central travel-way for cars, trucks, and transit vehicles. Each zone and use has minimum standards and each street type has overall design standards for speed and capacity.

The 'Transit Boulevard' is the largest street section at 50 meters because it accommodates a central dedicated transit area for BRT type facilities. A four lane 'Avenue' at 42 meters provides generous street side zones for pedestrians, bikes and bus stops. One-way street pairs called 'Couplets' are narrow at 30 meters and pedestrian friendly while carrying large volumes of traffic. 'Auto-free' streets enhance retail and bike routes and 'Local Streets' complete the network with a fine-grained access system.

Standards for the aspects of networks are as follows:

Block Size: 100 - 200 meters per side

Through street frequency: At least 250 meters on center

Right of Way Dimension: Maximum of 50 meters for Transit Boulevards, 42 meters for Avenues, 30 meters for Couplets and 20 meters for local streets

Street Capacity: Maximum 4 lanes of mixed flow traffic per ROW either one way or two way.

Street Density: 50 intersections per square kilometer minimum

Standards that apply to the typical elements in all these streets are:

Pedestrian Zone: 3-5 meters

Bike Zone: 2-4 meters

Flex Zone: (a flexible area next to travel lane used for turn lanes, drop off areas, bus loading areas, taxi zones or street trees) minimum 2.5 meters

Side Travel Lane: 3.5 meters

Interior Travel Lane: 3 meters

Table 3.1: Street Standards

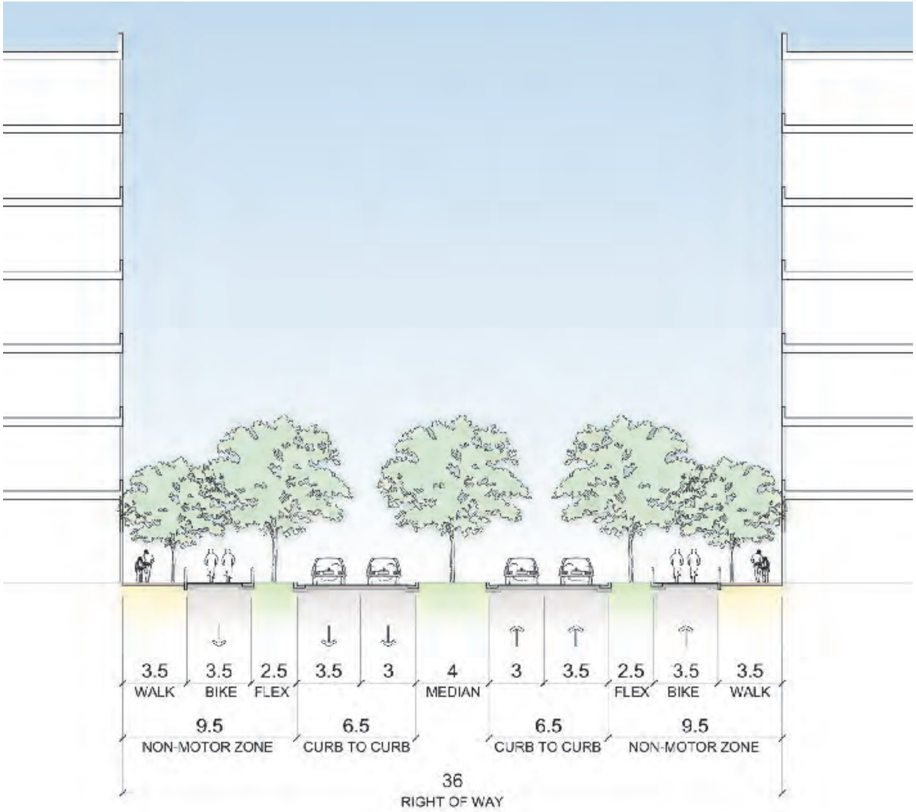
		City Size (population)	Existing Street Classifications				Recommended Street Classifications				
			Express-way	Arterial	Secondary Arterial	Local Street	Transit Boulevard	Couplet	Avenue	Local Street	Auto-free Street
Design Speed *(km/h)*	'Big City' category	>2,000,000	80	60	40	30	60	60	40	30	-
		<=2,000,000	60-80	40-60	40	30	40-60	40-60	40	30	-
Road Density *(km/sq km)*		>2,000,000	0.4-0.5	0.8-1.2	1.2-1.4	3-4	1 min.	3-4	3-4	3-4	2 min.
		<=2,000,000	0.3-0.4	0.8-1.2	1.2-1.4	3-4	1 min.	3-4	3-4	3-4	2 min.
Number of Vehicle Lanes		>2,000,000	6-8	6-8	4-6	3-4	4	3	4	3	-
		<=2,000,000	4-6	4-6	4-6	2	4	3	4	2	-
Right-of-Way *(m)*		>2,000,000	40-45	45-55	40-50	15-30	40-50	25-30	36-42	15-20	-
		<=2,000,000	35-40	40-50	30-45	15-20	45	30	40	15-20	-
			Current National Street Standards*				Urban Network Street Standards				

** Current national standards are based on: 1991 (CJJ 37-90) Code for Urban Road Design, 1995 (GB 50220-95) Code for Transport Planning on Urban Road*

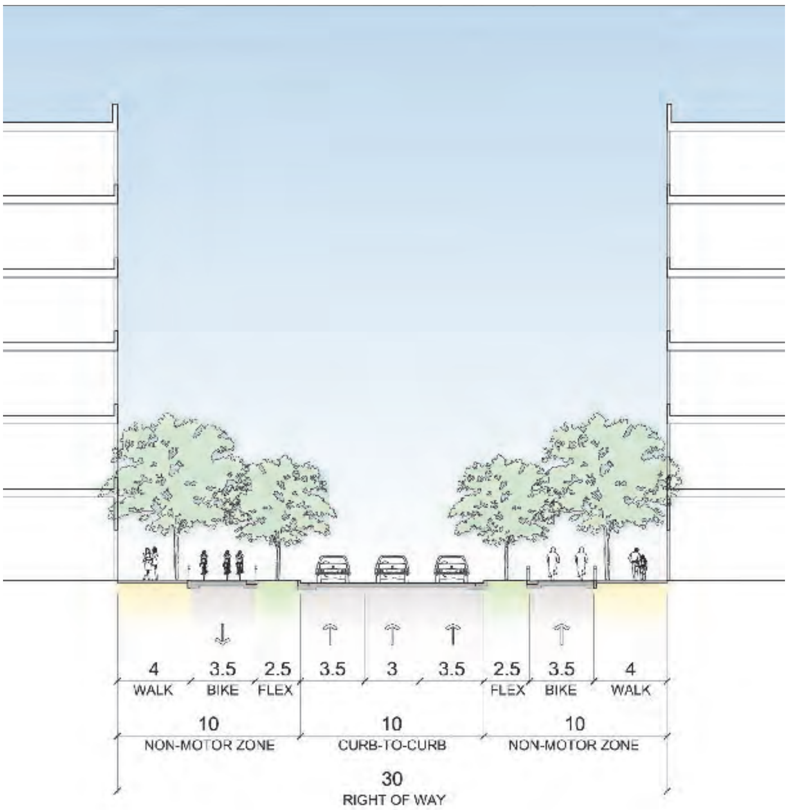
TYPICAL STREET SECTIONS

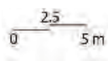
A. Transit Boulevard 50 m ROW

B. Avenue 42 m ROW

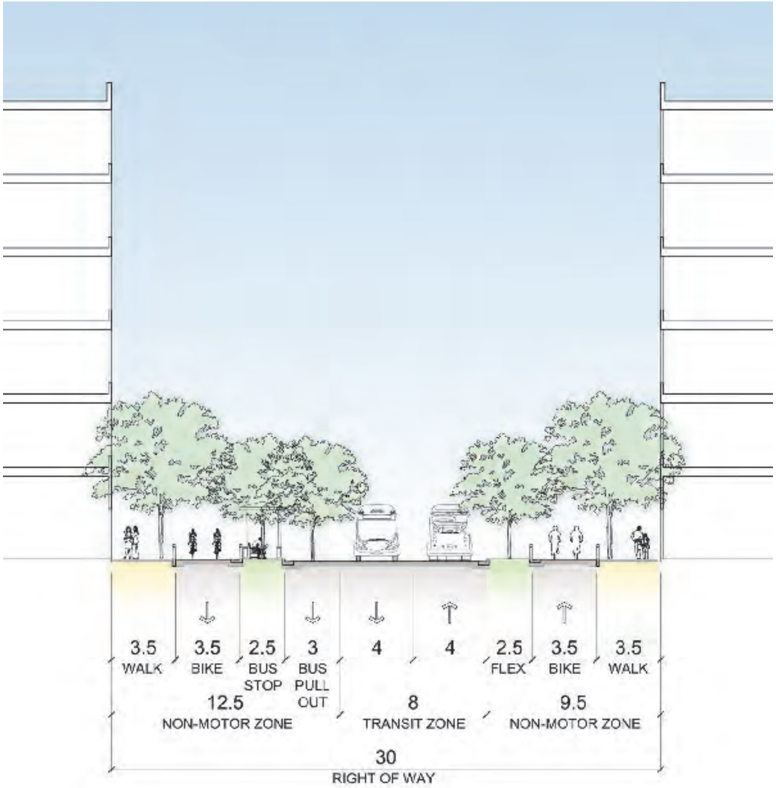


C. Avenue 36 m ROW

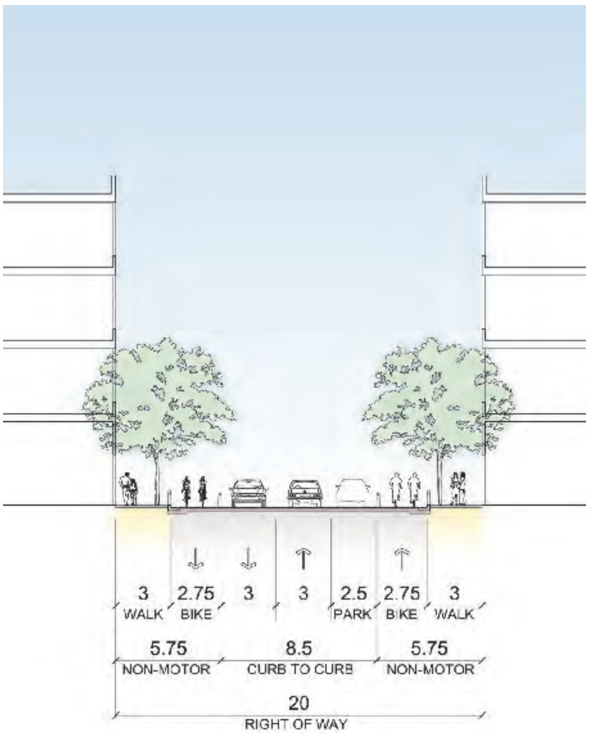




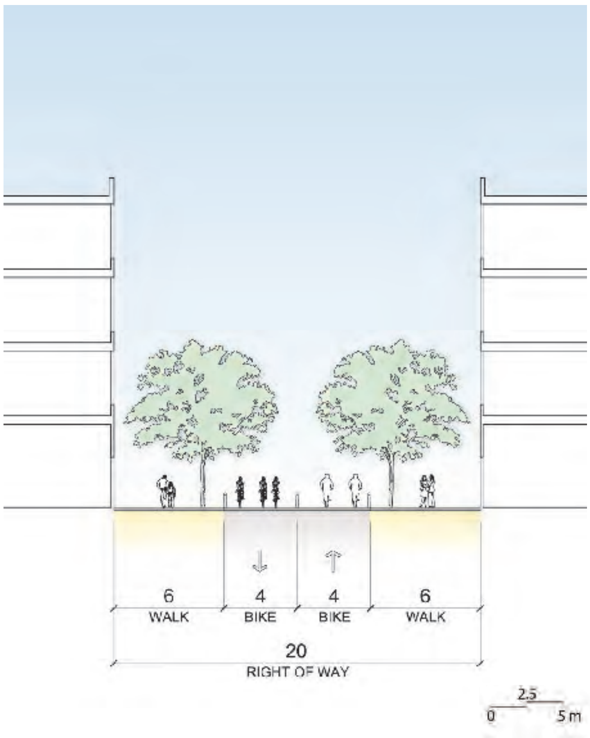
D. Couplet 30 m ROW



E. Transit Street 30 m ROW



F. Local Street 20 m ROW



G. Auto-free Street 20 m ROW

DEVELOPING AN URBAN NETWORK

The following design strategies apply to developing an Urban Network using these street types:

1. When entering a Transit Oriented District (TOD), Major Arterials of six travel lanes or more are converted into pairs of one-way streets (couplets) separated by approximately 100 meters. At the boundaries of TODs the standard configuration for a major arterial can be maintained, as pedestrian crossings are less frequent given the change in land-use. One-way couplets carry higher volumes of traffic more efficiently while providing pedestrian friendly edges and crossings.

2. Secondary Arterials of four to six lanes are extended into the TOD but must be redesigned to a smaller section with a maximum of four lanes and with additional attention to pedestrian and bike areas. Typically these 'Avenues' are more frequent than the spacing of Secondary Arterials and thereby help distribute through traffic onto smaller streets.

3. Special 'Transit Boulevards' are placed at the center of the district and carry high capacity bus lines and/or BRT. These streets allow for a center zone of 15 meters to accommodate dedicated bus lanes and station areas and typically measure 50 meters at stations, 42 meters elsewhere.

4. Auto-free streets can be used for special retail zones or as 'greenway' connections through the district that provide a major bike route to key destinations. They can also be used as transit-only streets to compliment the BRT oriented Transit Boulevards. In special cases they can be used for steep areas employing escalators and stairways to provide direct access where cars cannot go.

5. Finally, Local Streets add access and continuity for local trips on foot, bike, or car. These narrow streets offer temporary on-street parking, segregated bikeways, and generous sidewalks. They are designed for slow traffic speeds and therefore employ traffic calming strategies.

Figure 3.6 demonstrates the transformation of the Superblock System into an Urban Network. There are many ways of modifying the street network to accomplish the dual goals of pedestrian and bike friendly environments that also accommodate vehicle needs. First and key to the approach is to provide redundancy in the network to disperse traffic and provide alternate routes in case of emergencies or blockages. Second is the need for signal synchronization and the use of one-way streets to reduce dwell time at intersections. Third is to provide adequate and convenient transit service to reduce the number of auto trips in a district. And fourth is to provide local street connectivity to allow short trips to avoid being forced onto major through-traffic streets.

The Urban Network described here employs all of these strategies and we believe is quite flexible in its application to specific site constrains. The case studies in Part IV demonstrate the range of conditions that can be easily accommodated.

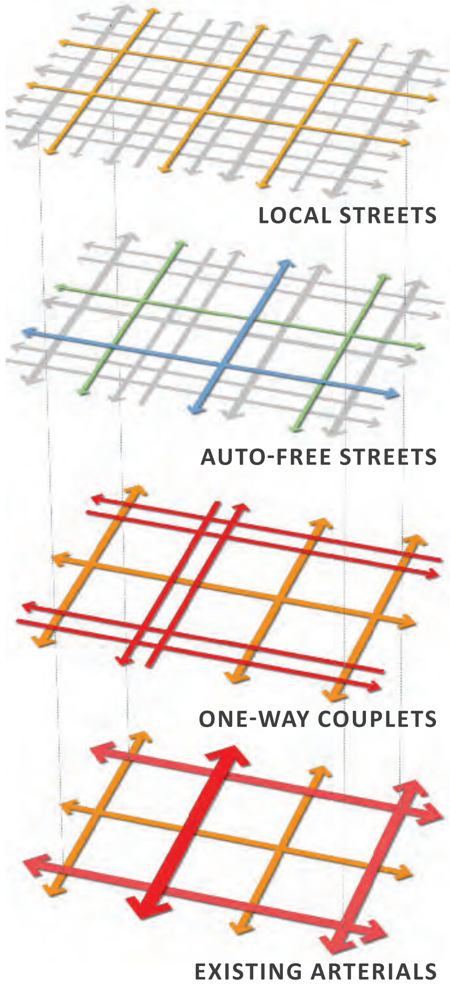


Figure 3.6: A critical part of the implementation process is the conversion of the superblock arterial network into a denser grid of narrower streets and smaller blocks without compromising road lane capacity. The diagram above is an illustration of how the various components of the suggested grid network work in conjunction to create a high-capacity, efficent circulation network.

Figure 3.7: Process of transforming a Superblock grid to a fine-grained Urban Network

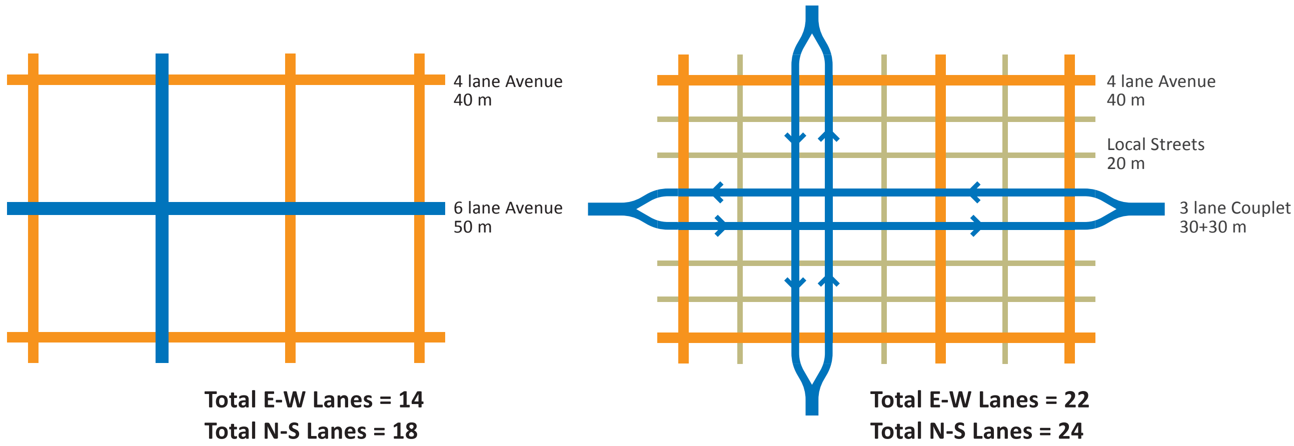
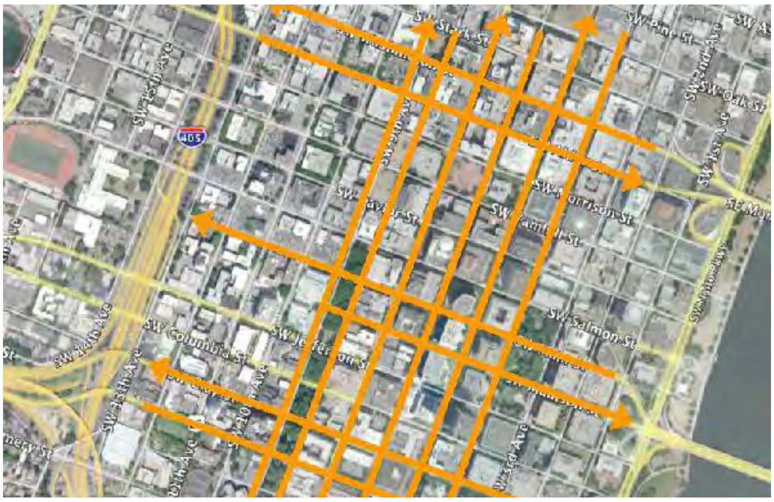


Figure 3.8: Examples of one-way couplets in Portland and Seattle.



Portland

Seattle

USE OF COUPLETS IN THE URBAN NETWORK

A key element of the Urban Network is the use of one-way streets in pairs to move high volumes of traffic without creating pedestrian barriers. These Couplets are typical in city centers throughout the world when suburban arterials and freeways enter urban grids. It is a traffic strategy that has been extensively tested and analyzed in many situations.

The potential benefits of implementing one-way ‘couplet’ streets and reduced block sizes in mixed-use developments or redevelopment areas are identified here. The intent is not to show that this street type should completely replace all arterial roadways; the results simply indicate that one-way couplets can achieve operational and safety benefits that make them a very viable alternative to the current development pattern of large roads and superblocks. The study includes a detailed description of one-way couplets and their general benefits as well as a computer-simulated operations analysis comparing conventional boulevards to couplets.

What are One-Way Couplets?

One-way couplets are parallel one-way roads with opposing traffic flow. Often in a downtown street grid, each one-way street in the couplet is separated by a block length that varies from 100 m to 200 m. Although one-way couplets serve many different areas including higher-density commercial, mixed-use town centers, and residential uses, they are used primarily to improve traffic flow in densely developed areas. One-way couplets are widely regarded by transportation specialists as a proven solution benefitting pedestrians, bikes, transit as well as automobiles.

One-way couplets have been widely used in many cities in the United States and Canada including San Francisco, New York City, Vancouver, Toronto, Seattle, and Denver, as well as many cities in Europe and Asia. In China, couplets are in operation in Guangzhou and in Beijing near Olympic Park. In downtown San Francisco, more than a dozen pairs of one-way couplets exist, with two to four travel lanes in each direction along with on-street parking and bike lanes on one or both sides of the roadway. Typically, each lane serves 600 to 700 vehicles during each peak hours. The relatively short block lengths create an attractive pedestrian environment while still adequately serving peak vehicle demand.

As described later, shorter block lengths and more frequent traffic signals can be accommodated with the simpler signal operation at each intersection and signal coordination along corridors that is only effective with couplets.

Overall, a system of one-way couplets would result in:

1. Improved traffic flow with less delay
2. More attractive facilities to increase walk and bike uses
3. Enhanced transit services
4. A safer environment for all transportation modes
5. More net land area available for development
6. Reduced fuel consumption and greenhouse gas emissions

Traffic Benefits

One-way couplets are designed to have higher intersection capacity than an equivalent two-way roadway due to fewer signal phases, less loss time between phases, and more green time for vehicle movements. Specifically, shorter crossing distances require less time for pedestrians and allow additional time for traffic to move unimpeded, which leads to better pedestrian compliance with the traffic control. Also, overall signal cycle lengths can be shorter resulting in less overall vehicle delay. The higher capacity results in better overall intersection operations and level of service (LOS). Even with high directional volumes, and most of the intersections along couplets operate at a level of service C or better during peak periods.

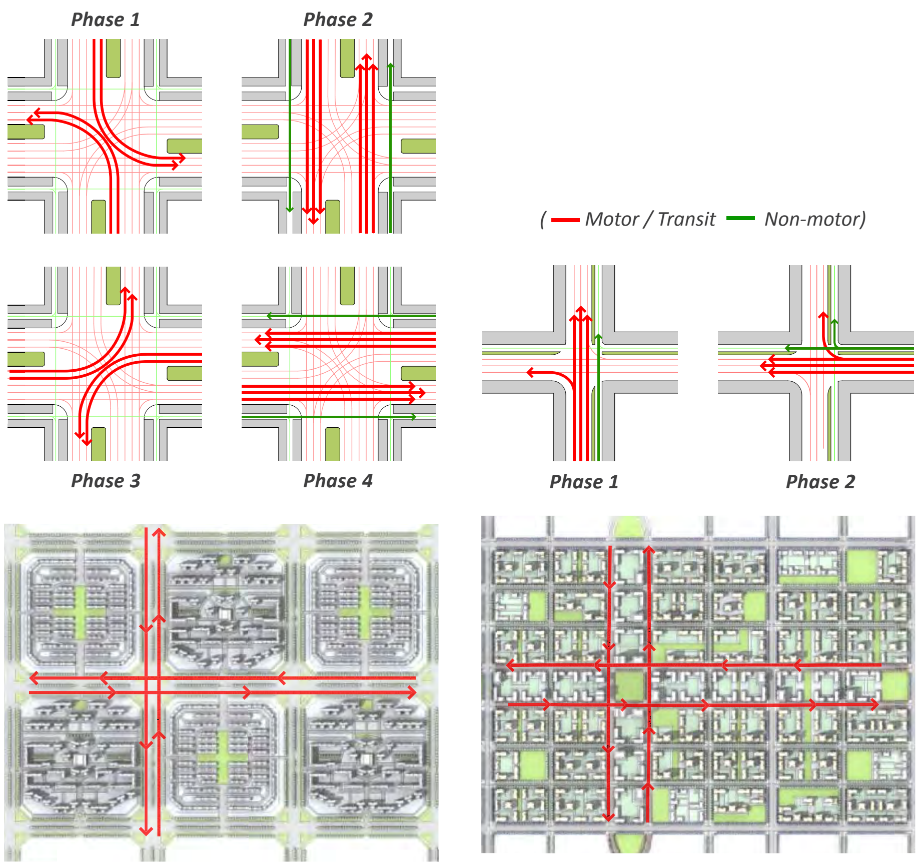


Figure 3.9: Comparison studies of traffic operations in a typical Superblock grid with conventional arterials (above) and an Urban Network with one-way couplets (below). Narrower one-way streets have fewer signal phases and reduce wait time at traffic lights, and also allow traffic signal coordination.

One-way couplets serve directional traffic and have fewer conflicting points, which allows for improved signal coordination between adjacent intersections along the couplets, as well as on cross streets. In contrast, signal coordination for the conventional arterial or boulevard is more complicated by having to coordinate two directions of travel on the same street. In addition, more widely spaced intersections allow platoons to disperse and efficient signal coordination is more difficult to achieve.

The reduced number of conflict points with one-way couplets also reduces the potential for collisions between vehicles and with bicyclists and pedestrians, thus improving overall traffic safety at intersections.

Overall travel times to and from local land uses are reduced because access is more direct with implementation of a couplet system and shorter block lengths. In many cases, driveways to and from fronting uses can be accessed without crossing opposing traffic.

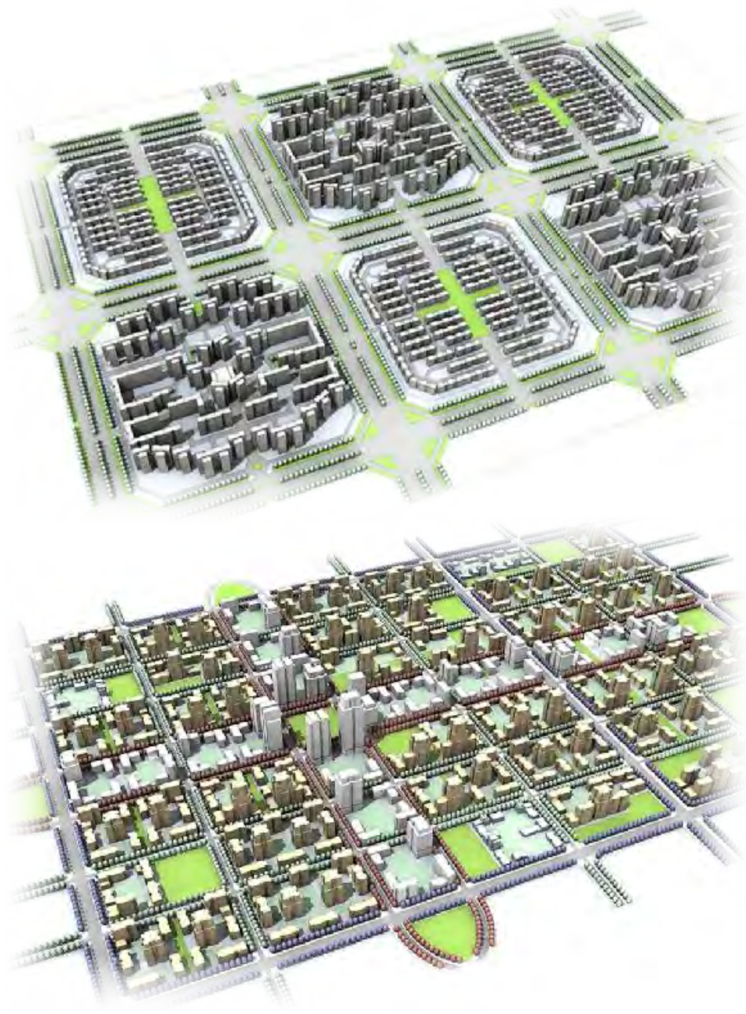
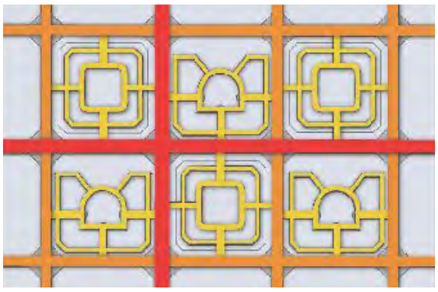
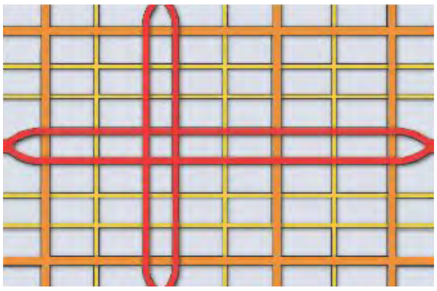


Figure 3.10: Illustrations of typical building massing within a Superblock System and an Urban Network. The Urban Network can accommodate a larger number of dwelling units (BUA) while maintaining smaller blocks and more variety in urban form.



Superblock with Conventional Arterials

Arterial ROWs = 24 Ha
Boulevard ROWs = 32 Ha
Local Street ROWs = 29 Ha
TOTAL = 85 Ha



Urban Network with One-way Couplets

Arterial ROWs = 20 Ha
Boulevard ROWs = 26 Ha
Local Street ROWs = 20 Ha
TOTAL = 66 Ha

Figure 3.11: Comparison of the area used for streets in a Superblock and an Urban Network

Transit Benefits

Bus transit operations will also be improved due to overall improved traffic flow along one-way couplets due to the increased roadway capacity. This will consequently reduce delay for buses and improve reliability of transit services.

With improved signal progression and reduced traffic congestion, the existing bus queuing problem at transit stops would be relieved. Also, shorter signal cycle lengths will facilitate bus services with high frequencies (with dispatching headways equal to or less than the cycle length) and improved headway regularity.

In addition, the improved walking and biking environment and connectivity between land uses under the one-way couplets in an Urban Network would increase the transit catchment area and potentially increase overall transit ridership and mode share.

Pedestrian / Bike Benefits

One-way couplets are designed to have narrower roadway cross-sections with fewer travel lanes and consequently shorter crosswalks for pedestrians. Compared to an equivalent two-way roadway, the required pedestrian clearance time for one-way couplet intersections is shorter by at least 50%.

With traffic likely dispersed to parallel roadways in the grid-like Urban Network, one-way couplets have lower number of turning vehicles at each location. This creates a safer environment for pedestrian and bike users to cross streets at intersections. In addition, if the pedestrian and bike activity is significant (which is the case in most cities in China), a protected pedestrian/bike phase could be provided without causing significant delays to turning traffic.

With shorter block lengths and improved signal progression, traffic on one-way couplets can be maintained at reasonable travel speeds. This provides a more pedestrian and bicycle friendly setting and enhances safety for all roadway users. The shorter blocks that are possible with couplets and signal progression also reduce the distance amount pedestrians to walk in order to reach signal-protected crossing locations. This can reduce the tendency for pedestrians to cross at unsafe mid-block locations.

Urban Design Benefits

Calthorpe Associates performed a right-of-way (ROW) area comparison between the superblock and couplet with grid systems (Figure 3.11). The superblock calculation assumes that there would be some internal circulation roadways to provide access within the super block area. Their analysis shows that the couplets system would require less ROW for roads (66 ha vs. 85 ha) than the superblock system for the same study area when local access roads within a typical superblock is included.

TRAFFIC OPERATIONS ANALYSIS

A traffic operations analysis was conducted by Fehr and Peers to evaluate the performance of a conventional arterial and a one-way couplet alternative. The generic study segment for this analysis was an approximate 1.5 to 2 km long section of street including a series of cross-streets that was representative of a comparable roadway network in a major city.

For the conventional superblock scenario, the main east-west roadway was assumed to be a six-lane, two-way arterial with on-street parking, bicycle lanes, and sidewalks on both sides of the street. Intersecting the east-west arterial are four streets in the north-south direction including a six-lane arterial with a similar cross-section, and three four-lane major arterials. The spacing between adjacent intersections is approximately 500 meters and represents a typical superblock design.

For the one-way couplet alternative, the main east-west roadway was assumed to be served by a one-way couplet with each street including three travel lanes, on-street parking, sidewalks and a bike lane. The east-west one-way couplet is intersected by eight streets running north-south: a one-way couplet (the equivalent of a six-lane arterial), with a similar cross-section, three major four-lane arterials and three minor two-lane local streets. The average spacing between adjacent intersections is about 150-200 meters.

Another key assumption for this analysis is traffic demand. The traffic demand was assumed at 900 to 1,000 vehicles per hour per lane to provide a conservative analysis and illustrate operations under conditions near the theoretical capacity of a conventional arterial in China. This assumption was confirmed by Beijing Planning Institute staff as consistent with their capacity threshold identified for the boulevard classification.

To capture the effect of all travel modes on traffic operations within each alternative study corridor, VISSIM, a comprehensive traffic analysis and simulation program, was applied. VISSIM has been widely used in complex transportation projects throughout the world and incorporates the effects of pedestrians, bikes, and transit on traffic operations. In addition to VISSIM, another widely used traffic signal timing and analysis software, "Synchro", was used to perform signal timing optimization and coordination for both the conventional arterial and the one-way couplet alternatives. The results of the operations analysis focused on intersection operations or level of service (LOS), corridor travel time, and fuel consumption.

In the first study, the traffic volumes used in the conventional arterial analysis were replicated in the one-way couplet alternative. That is, the analysis assumed that the total east-west and north-south volumes passing through each system were exactly the same. Figure 3.12 compares the results between the two street configuration alternatives assuming the same volumes in each system. For the one-way couplet alternative, 5 of the 16 study intersections or roughly 30% would operate near capacity with LOS E conditions, while all of the other locations would operate with limited delay at LOS D or better. In contrast, the conventional arterial alternative shows that

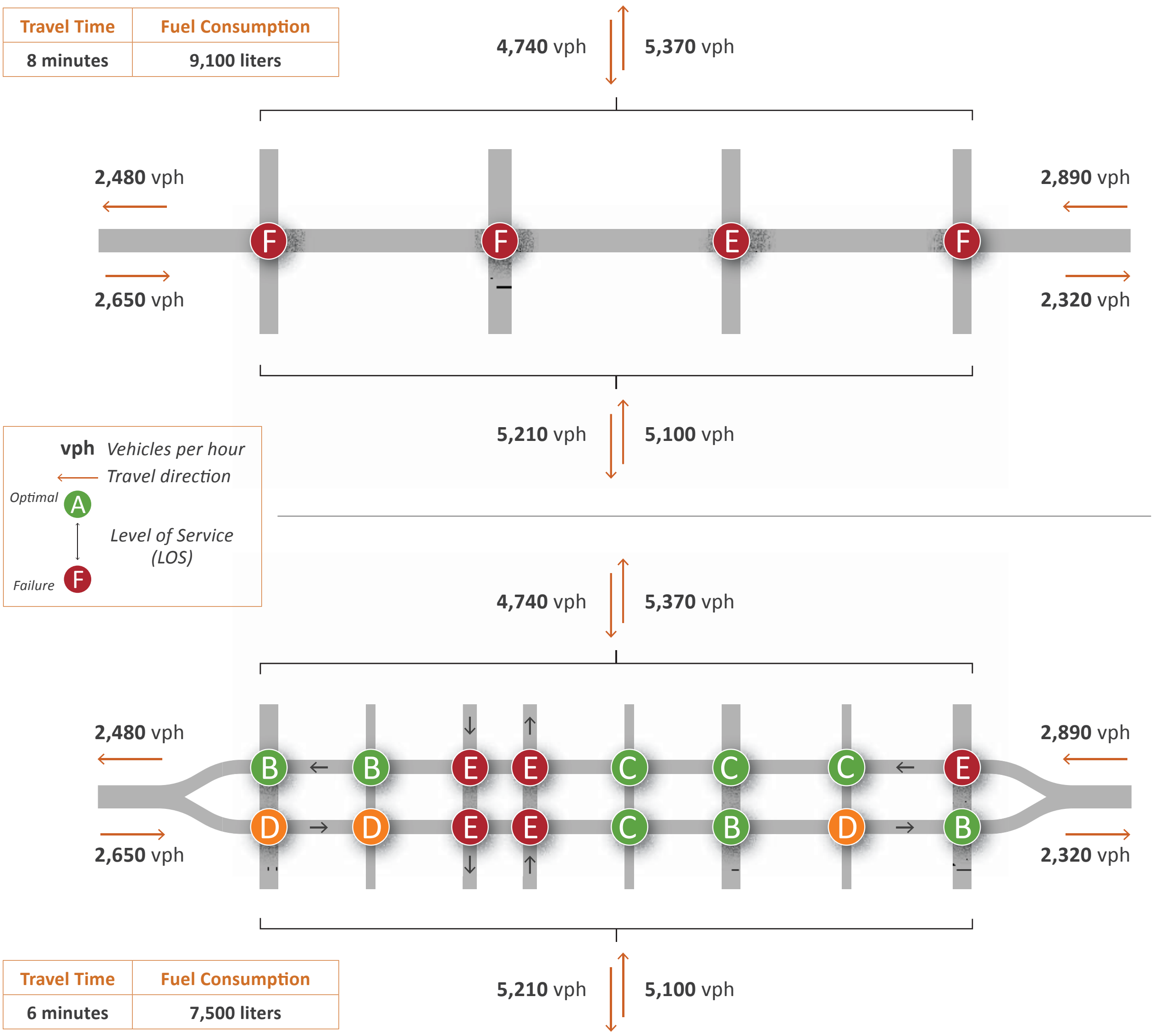


Figure 3.12: Traffic flow comparison between a conventional six-lane arterial (above) and a one-way couplet alternative (below) with equal traffic volumes

only one intersection would operate near capacity at LOS E and all other intersections would be over-saturated and operate at LOS F conditions.

To quantify the cumulative effect of delay at each intersection, travel time was measured for the same east-west segment across each alternative. The average travel time for the one-way couplet alternative was six minutes, or two minutes shorter than the conventional arterial alternative. This reduction compared to the standard arterial illustrates that signal progression is substantially better with fewer signal phases at each couplet intersection. In addition, the hourly fuel consumed by vehicles traveling in the couplet network is about 7,500 liters, which is 1,600 liters or 18% less

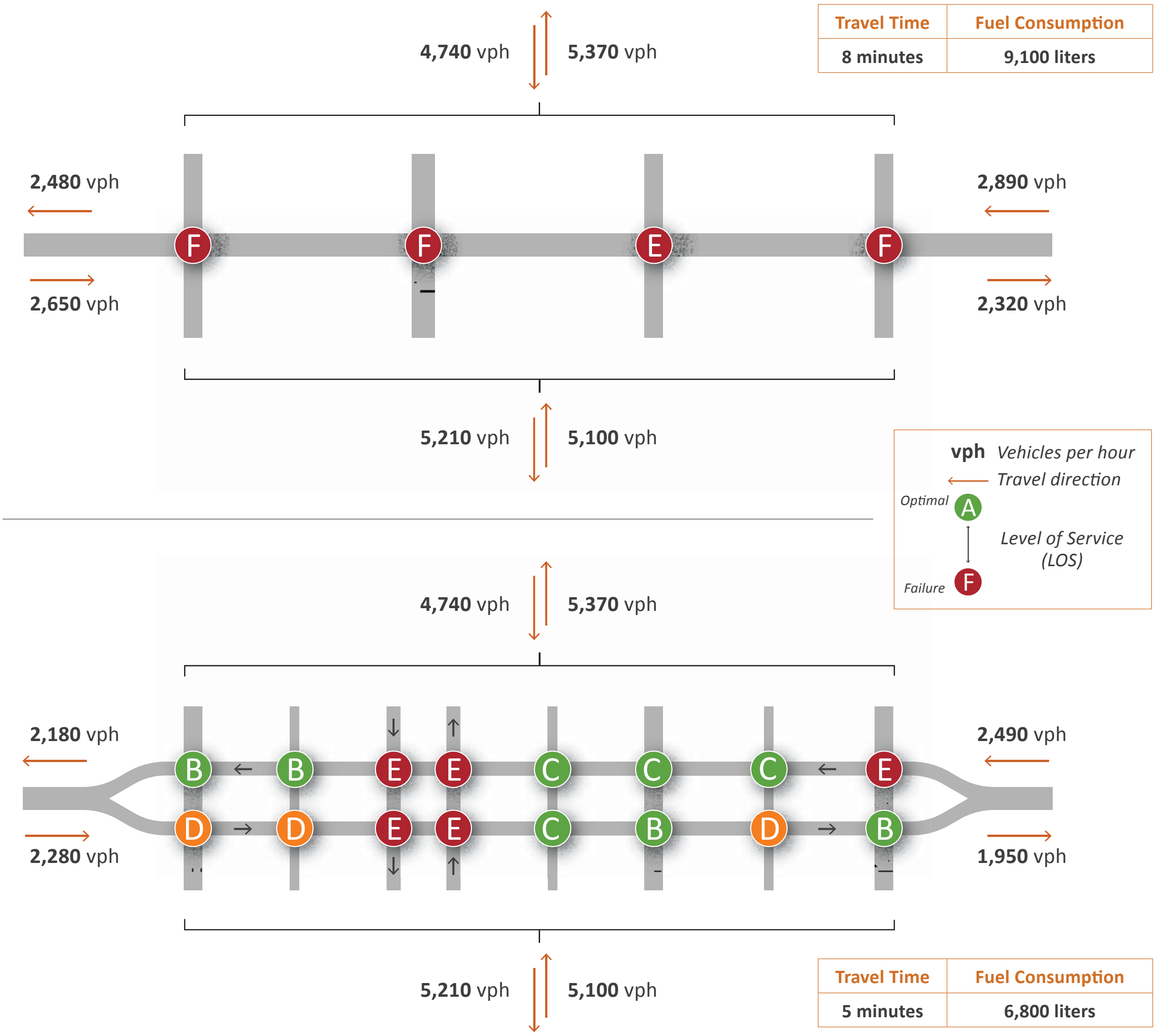


Figure 3.13: Traffic flow comparison between a conventional six-lane arterial (above) and a one-way couplet alternative (below) with dispersed traffic volumes

than the conventional arterial alternative at 9,100 liters. In reality, traffic would be more dispersed with a road network that included more cross streets both north-south and east-west (because of parallel capacity). Therefore, traffic demand on the one-way couplet streets would be less than that on the conventional arterial serving superblocks. This is a more realistic set of assumptions and analysis.

The traffic volume on the east-west couplet streets is estimated to be approximately 15% less. For this analysis, only the traffic on the east-west couplet street was reduced and analyzed using VISSIM. As shown in Figure 3.13, the overall traffic benefits of the one-way couplets with dispersed volumes are even greater than the scenario with equal traffic volumes and are more realistic. For the one-way couplet alternative, only 12 percent or 2 of the 16 study intersections would operate near capacity at LOS E and the remaining intersections would operate with adequate capacity at LOS D or better. Travel time measured for the same segment shows an average travel time of 5 minutes for the one-way couplet compared to 8 minutes for the conventional arterial alternative or a 38% reduction. In addition, the hourly fuel consumed by vehicles traveling in the one-way couplet network is about 6,800 liters, which is 2,300 liters or 25% less than the boulevard alternative.

In addition to the specific benefits shown in Figures 3.12 and 3.13, additional measures were obtained from the VISSIM models to quantify system-wide traffic benefits. These included overall vehicle delays and the number of vehicles able to pass through the network within the peak hour. For the conventional arterial network the total vehicle hours of delay (VHD) amounted to 860 hours, while the couplet alternative resulted in a total VHD of 640 hours or 25% less. Similarly, the couplet alternative was able to serve six percent or 800 more vehicles through the study area within a one-hour period than the conventional arterial alternative, due to higher delays and resulting queues on the conventional arterial alternative. Because the couplet alternative is able to serve more traffic within a one hour period, the fuel consumption savings cited above are considered conservative. The fuel used by vehicles not served or queued outside the system is not included, and the actual fuel savings is expected to be substantially higher than 18% to 25%.

Table 3.2 summarizes the measures of effectiveness comparison between the conventional arterial and the one-way couplet alternative assuming equal volumes (i.e., no dispersion due to the smaller blocks and grid network). In addition to traffic operations measures, the crossing distances and subsequent minimum required crossing times are included. The crossing distance assumes the following: three through lanes and bike lane in each direction plus a separate left-turn lane for subsequent minimum required crossing times are included. The crossing distance assumes the following: three through lanes and bike lane in each direction plus a separate left-turn lane for the conventional arterial, and three through lanes, a separate left-turn lane, and a bike lane for the one-way couplet street (one segment only).

Table 3.2: *Measures of effectiveness comparison between the Conventional Arterial and Couplet*

Measure of Effectiveness	Conventional Arterial	One-way Couplets (Equal Volumes)
Pedestrian crossing distance	**33.0 meters**	**17.4 meters**
Minimum pedestrian crossing time	**35.2 seconds**	**18.6 seconds**
Number of signal phases	**4 to 8**	**2 to 5**
Range of Level of Service (LOS)	**LOS ‘E’ to ‘F’**	**LOS ‘B’ to ‘E’**
Number of LOS ‘E’/’F’ intersections	**4 of 4 (100%)**	**5 of 16 (31%)**
Major corridor travel time	**8 minutes**	**6 minutes (25% less)**
Vehicle hours of delay	**860**	**640 (25% less)**
Fuel consumption	**9,100 liters**	**7,500 liters (18% less)**
Percentage of vehicles through system	**91%**	**97%**

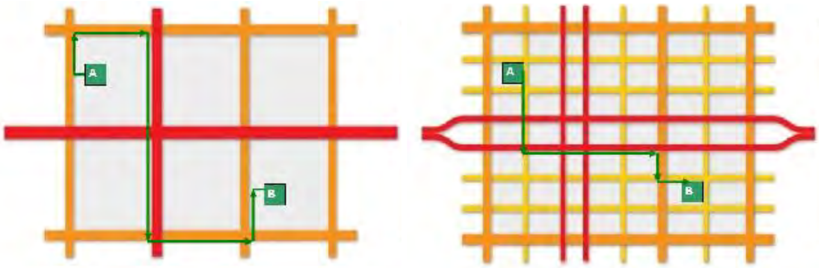
VEHICLE TRAVEL DISTANCE EVALUATION

The traffic operations analysis above focused on corridor-wide and system-wide operating conditions. Other issues for comparison between the two roadway configurations include the difference in travel distance and number of turns required to travel between various points within the overall network. The concept of the one-way couplets and its supporting highly connected urban roadway network is known to reduce, rather than increase, vehicle miles traveled and travel times. Compared to the superblock system, destinations are better accessed by more parallel streets in the highly connected grid system so that drivers can drive shorter routes.

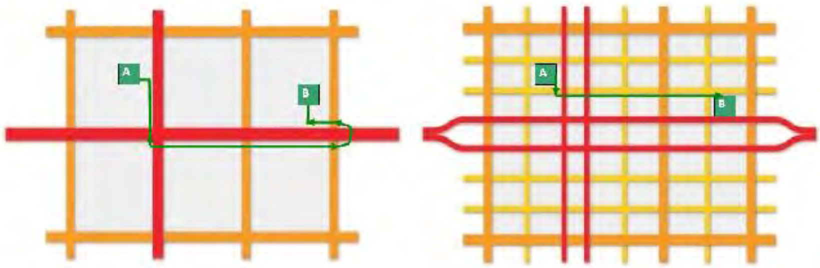
Fehr and Peers compared the shortest travel distances between the superblock and couplet systems for four different origin-destination (O-D) pairs, which are shown in Figure 3.14. As shown in three out of the four cases, the shortest travel distance in the couplets system is 150 to 1,000 meters shorter than the superblock system. For the case that the couplets system requires a longer travel distance, the difference is only 150 meters. Although traveling on the couplets is approximately 8% greater in distance (150 m / 1,850 m) in this one case, the travel time along the couplets corridor is estimated to be approximately 10% to 15% less than the superblock system.

Compared to the superblock system, the one-way couplets system would provide more opportunities for drivers to choose and change alternative travel routes; however, this does not necessarily result in more turns. As shown in the four figures on the following pages, the number of turns under the couplets system is less than the superblock system for two out of the four O-D pairs and is same as the superblock system for one O-D pair. For the last O-D pair, the couplets system would include one more turn than the superblock system. In this case, a driver may have to make one or two additional turns but they would be low-conflict turns and entail shorter travel distance and travel time than would be the case with attempting to make U-turns at widely-spaced, high-volume, and high-conflict intersections in the conventional superblock network configuration.

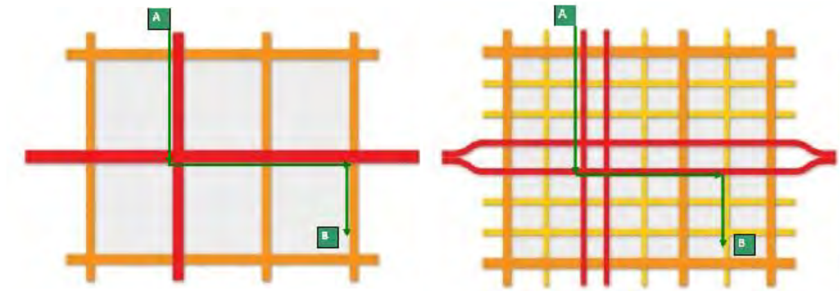
SCENARIO 1.1		
Travel from A to B	*Superblock Grid*	*Urban Network*
Number of turns	4	3
Travel distance within study area	2,400 m	1,400 m
Length of travel on arterial streets	2,400 m	850 m



SCENARIO 1.2		
Travel from A to B	*Superblock Grid*	*Urban Network*
Number of turns	2 *(Including U-Turn)*	1
Travel distance within study area	1,350 m	900 m
Length of travel on arterial streets	1,350 m	100 m



SCENARIO 2.1		
Travel from A to B	*Superblock Grid*	*Urban Network*
Number of turns	2	2
Travel distance within study area	1,800 m	1,650 m
Length of travel on arterial streets	1,800 m	1,250 m



SCENARIO 2.2		
Travel from A to B	*Superblock Grid*	*Urban Network*
Number of turns	1 (U-Turn)	2
Travel distance within study area	1,850 m	2,000 m
Length of travel on arterial streets	1,850 m	1,900 m

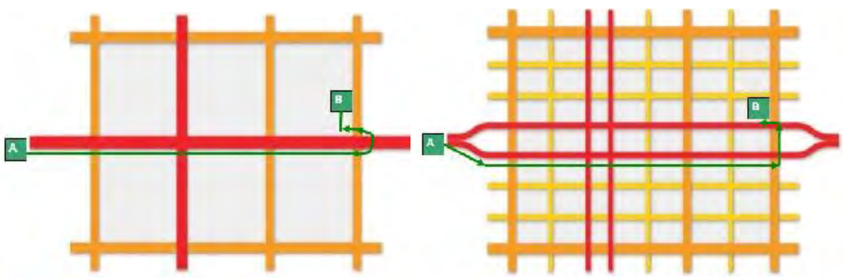


Figure 3.14: Travel distance comparison between conventional arterials and one-way couplets.

Note: For superblocks, it is assumed that only right-turn-in/out is allowed for driveways along arterials.

COUPLET IMPLEMENTATION

The following steps were recommended for the implementation and design of one-way couplets in China:

Location of Couplets

Based on the refinement of land use plans for several large-scale redevelopment projects or new developments in China, it has been observed that the size of urban blocks is being reduced to achieve urban design and circulation goals. This is leading to a more fine-grained grid pattern, which is a step in the right direction. However, increasing the number of cross-street intersections on a conventional two-way arterial will result in worse traffic operations, especially in high-volume corridors. In addition, maintaining longer pedestrian crossings will result in lengthy delays compared to those that would be required for a couplet street. Thus, couplet streets should be strongly considered for locations where the block sizes will be less than 200 m and medium to high traffic volumes are anticipated on higher capacity streets.

Traffic Management

One of the key factors that lead to success of the one-way couplets is optimized signal timing and coordination plans, which requires not only technical equipment in place (i.e., signal controllers, system-to-system communications, detection system, etc) but the resources to optimize and fine-tune signal operations and coordination parameters. According to a recent signal coordination study in Southern California in the United States, optimal signal coordination plans can reduce corridor travel times and delays by 15 to 20 percent. In China, this signal timing adjustment/implementation effort is typically done by the Traffic Control/Management Bureau. Therefore, providing relevant signal timing training to those traffic management staff is critical to the success of one-way couplets concept in China.

This study reveals the traffic, pedestrian/bicycle, and transit benefits of the couplets concept, and those benefits ultimately lead to a more sustainable and "green" transport system. One-way couplet streets provide benefits to pedestrian and bicycle travel by reducing the overall street section and minimizing the number of conflict points with vehicles. The resulting traffic operations benefits show that implementation of couplets enhance travel for all modes including transit, and are environmentally superior to conventional arterial roadways in terms of fuel consumption and reduced greenhouse gas emissions. In addition, couplet streets successfully operate in many cities and are an effective urban design tool in providing walkable and attractive pedestrian environments. For Chinese cities where a majority of trips are made by non-automobile modes, the use of couplets would complement the existing mode split and enhance traffic operations in planned corridors compared to the standard arterial and superblock design.

IV CASE STUDIES

CASE STUDY 1: CHENGGONG NEW TOWN

Figure 4.1: A bird's eye view rendering of the Urban Design Concept for Chenggong New Town

Kunming, the capital of Yunnan province, has been the focus of tremendous urban expansion over the past decade. Chenggong, the largest of the four planned new towns, will become the new provincial capital and home to the new Yunnan University. The site for the new town, located 15 km south-west of Downtown Kunming with an area of 160 sq km, will extend from the foothills of a mountain range on the east to the banks of the picturesque Dianchi Lake on the west.

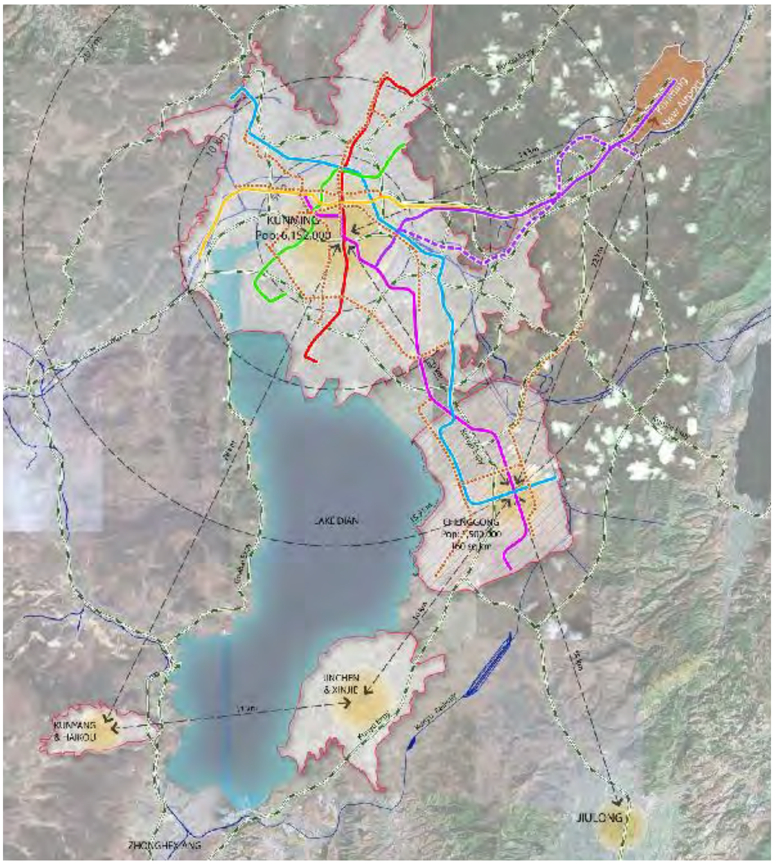


Figure 4.2: Chenggong New Town Regional Analysis Map

At present, the population of Chenggong is estimated to be 300,000 but is expected to reach 1,500,000 over the next twenty years, with over 625,000 jobs incorporated into mixed-use districts. In recognition of the ecological wealth of the region, development principles for the region are based on promoting 'Low-Carbon Cities'. A robust transit network comprising of several bus rapid transit (BRT) lines and two Metro lines will integrate Chenggong with the historic city and other planned areas.

An indication of the importance of Chenggong is its planned High Speed Rail Hub at Kunyu Rail Station which will ultimately serve an estimated 200,000 passengers each day. Its three High Speed Rail lines will connect Kunming to Shanghai, Chongqing and Guangxi. It is estimated that by 2020, the annual number of passengers would reach 31.2 million and by 2030, 44 million. There are also proposals to extend the rail network across the border to South East Asia.

Another key development for the new town is the proposed Yunnan University, a major new center for education, research and related fields. It will establish Chenggong as a knowledge base for the entire region. It will have a comprehensive mix of academic and research facilities as well as residences for teachers and displaced villagers. It will have a total student population of 150,000 with approximately 20,000 teachers in a number of colleges spread over 1,500 ha.

Figure 4.3: Dianchi Lake is popular feature in the Chenggong region

Kunyu Rail Station

Yunnan University

The Government Center

The Government Center park area

Figure 4.4: Key planned development include top left, the planned Kunyu Rail Station; top right, Yunnan University; and bottom left and right, the Government Center and surrounding park area

Existing development in Chenggong follows the standard 'Superblock' model with gated, single-use zones within parcels averaging 500 meters per side. Typically the blocks are filled with similar buildings and the streets are inhospitable to pedestrians and bikers. Within some projects ad-hoc shops have developed to satisfy the desire for local street life and services.

Figure 4.5: Ongoing development in some parts of Chenggong features the superblock grid with wide arterial streets. Despite the high quality of architecture and landscape, the development fails to create an inviting environment for the pedestrian.

Figure 4.6: Images of superblock neighborhoods in Chenggong. Though the design and layout of the typical superblock does not encourage ground floor activity through shops, etc. (left image) the desire for such daily conveniences manifests itself in the form of unauthorized shops and 'street-side cafes' in the back alleys of the superblock (right image).

Central District TOD Design

The plan for Chenggong's central district is a good example of the planning methodology outlined in this document, and of the design principles listed in the introduction. At the Master Plan level the new town meets the fundamental criteria for sustainable low-carbon design by creating an overall jobs/housing balance, and providing rich transit opportunities. What it lacks however are walkable, mixed-use neighborhoods and transit centers. Overall it is compact, dense, and served by multiple transit lines and technologies. These features facilitate its design as a series of TODs. In addition its physical footprint respects the natural environment, preserving and enhancing the lake edge as well as the natural topography of local hills and the surrounding mountains.

Figure 4.7: A rendering of the plan for Chenggong New Town Central District

Given this basic framework, the New Town demonstrates how sustainable design can be applied to an 'in-progress' development area. First TODs are located within the master plan: Several special use areas dedicated to the university and industrial use are excluded. Then the open space and areas dominated by existing construction are identified. There remain four potential TOD areas that meet the land-use and transit criteria defined in Section 2. Of these four one, the 'Central District', was selected for modification in the regulatory plan.

This 'Central District' is bounded by an expressway to the west, open space and existing development to the north, and the university on the other sides. It has two metro lines with 6 stations, one of which is a major multimodal station combining the two metro lines. In addition there are multiple BRT routes and stations along with the high-speed rail station. In all, this rich transit network creates one 'Commercial Center', four 'Urban Centers' and seven 'Town Centers' as defined by the Manual. These station areas and their transit capacity then sets the hierarchy of density and mix within the overall Central District TOD.

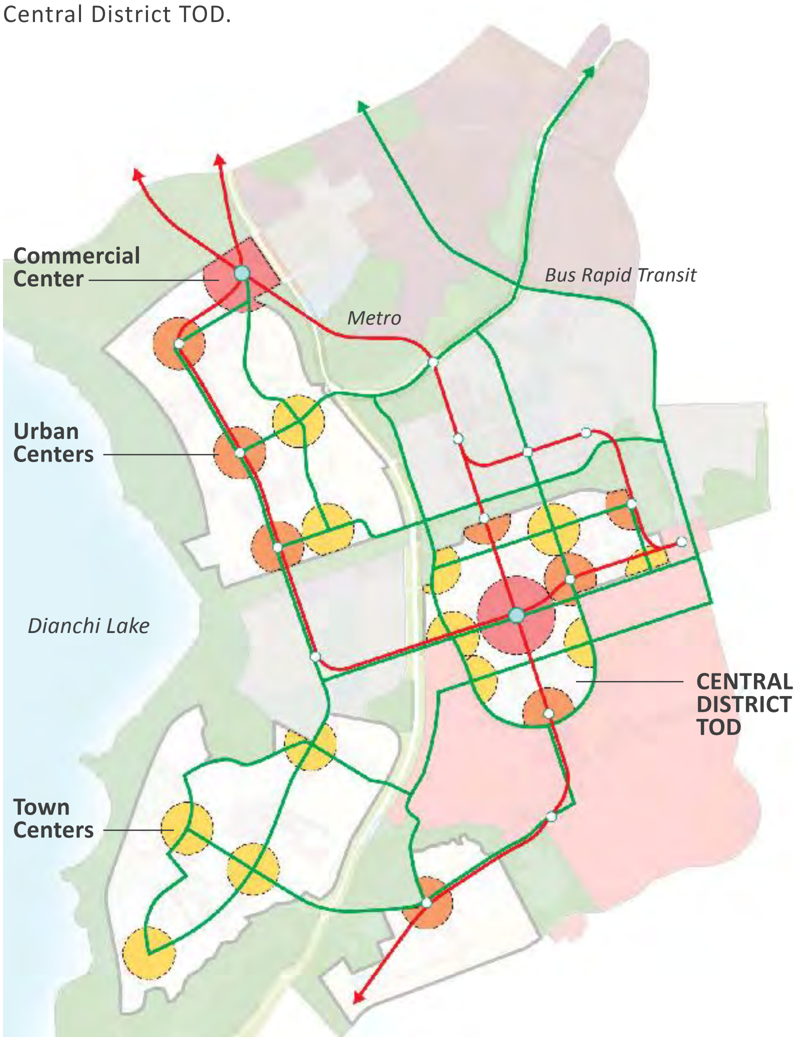


Figure 4.8: The Chenggong New Town plan with location of TODs and Centers highlighted

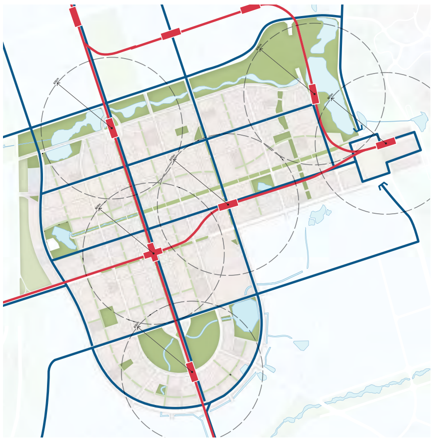
Regulatory Design

After designating the TOD area with its Transit Centers, the overall plan for the area is developed using the Urban Network street system and detailed 'Small Blocks' zoning. As construction of the old Superblock street network was already underway, the street easements and in some cases the completed street sections where modified. Foremost the central boulevard, Caiyun Road, a ten-lane arterial measuring over 80 meters was modified into a series of 'park blocks' with small one-way streets on each side. Rather than a central axis dominated by traffic and cars, the District now centers on green space that is pedestrian, bike and transit friendly.

Other major through roads were modified into pairs of one way couplets to provide for large volumes of cars without becoming barriers to the pedestrian. Numerous auto-free streets were added to provide more opportunities and convenience for bikers and pedestrians. Finally local narrow streets added access to the individual blocks. The result is a human scaled street and block system which averages 50 intersections per square kilometer and has blocks that average 1.5 ha each. The pedestrian never has to walk more than 70 m to reach an intersection and the crossing of travel lanes is never more than 12 m.

Figure 4.9: Caiyun Road – planned as a ten-lane arterial 80 m wide (aerial above) was reconfigured as a one-way couplet with park blocks creating a green pedestrian spine through the center of the Central District

Figure 4.10a-c: Chenggong Central District circulation planning:



(a) Transit plan showing the Metro (red) and BRT (blue) network

(b) Arterial network with the use of one-way couplets to create a high-capacity street network without compromising pedestrian scale

(c) Auto-free streets were introduced to provide a complementary circulation network for pedestrians and bikes.

In all cases the redesigned street sections provides generous areas for pedestrians and safe, protected lanes for bikes. And perhaps just as important, the zoning requires buildings at the sidewalk with shops, cafes, and useful ground floor activities. Street-life and walkability are at the heart of the new street network.

Next the human-scaled blocks are zoned using six typical 'small blocks ranging in density from 4.0 to 2.7 FAR for residential blocks and 8.0 to 4.0 for commercial. Each of these 'small blocks' have a series of design standards which establish typical development controls as well as detailed urban design criteria that insures each development will contribute to the human scale character and low carbon goals of the district. By clustering high density and commercial 'small blocks' at the key transit stations, the district gains a varied skyline as it rationally distributes jobs and housing close to transit opportunities. Foremost is the commercial area of approximately a million square meters located at the crossing of the two Metro lines. This area becomes effectively the focal CBD of the new town and the new town's regional retail destination.

Finally civic elements such as parks, schools, and public facilities are located to enhance their accessibility without auto use. The linear parks that cross the site give an overall framework and primary orientation for all. The end result is that no child must walk more than 400 meters to a school or local park and residents never more that 400 meters to a transit station.

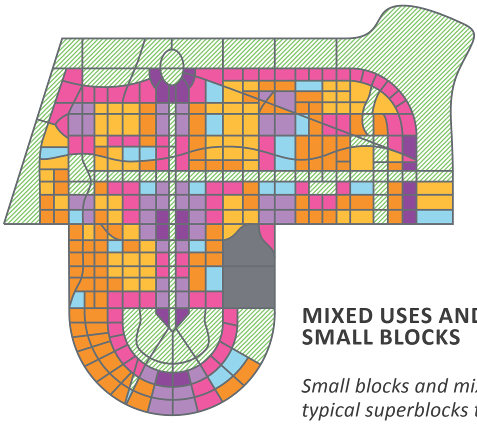
Figure 4.11: CBD Design within the Chenggong Central District focuses high density development at the metro station

Figure 4.12: Chenggong Central District Illustrative Plan

In sum, the design for Chenggong's new town Central District manifests the goals and criteria of this manual's eight principles:

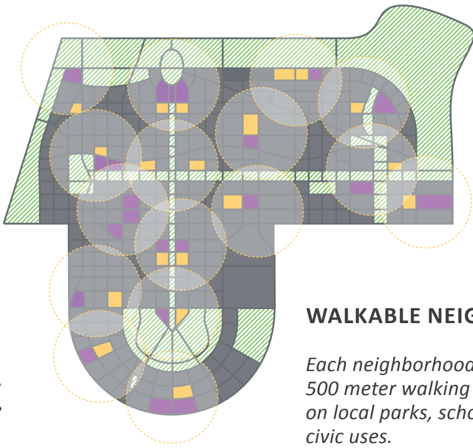
1. The focus of its new street system and land-use standards enhances the pedestrian and the street life that makes walking pleasurable and useful.
2. By providing frequent, safe bike routes as well as auto free streets, biking becomes a priority in the District.
3. The dense network of streets and small blocks provide a varied, human-scale environment that creates the right context for alternative modes of transportation.
4. The multiple transit lines and central location of the stations will help to balance trips and provide easy, efficient transit utilization.
5. Providing for mixed-use throughout the TOD will allow for local street life and short trips.
6. By clustering commercial density at the highest capacity transit station, peak hour commute trips will be dispersed and become multi directional
7. The overall plan, density, and transit connections of Chenggong works well in the City Master Plan to rationalize growth at the large scale.
8. Finally the emphasis on walking, biking and transit will be reinforced by parking standards and transit accessibility.

In all this is a clear example of how to define a TOD with its various Centers and how to design in detail for a sustainable, low carbon city.



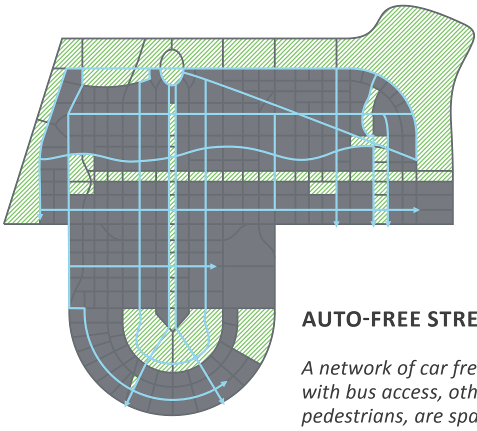
MIXED USES AND SMALL BLOCKS

Small blocks and mixed uses replace typical superblocks to create a more walkable community. The greater street density improves pedestrian access and disperse traffic.



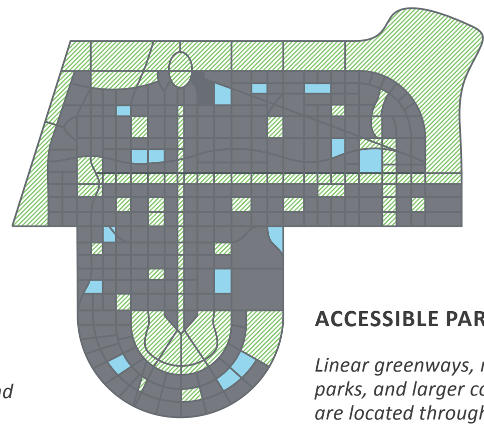
WALKABLE NEIGHBORHOODS

Each neighborhood has a roughly 500 meter walking radius, centered on local parks, schools, and other civic uses.



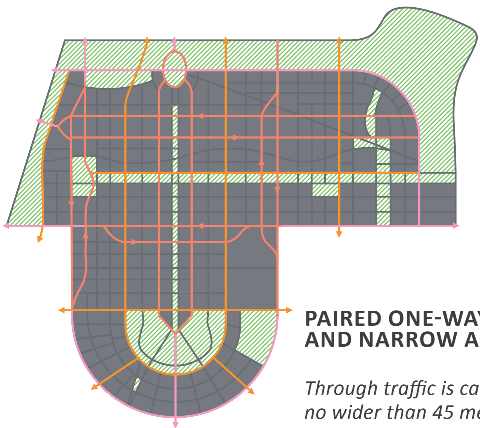
AUTO-FREE STREETS

A network of car free streets, some with bus access, others for bikes and pedestrians, are spaced no more than 800 meters apart throughout the town.



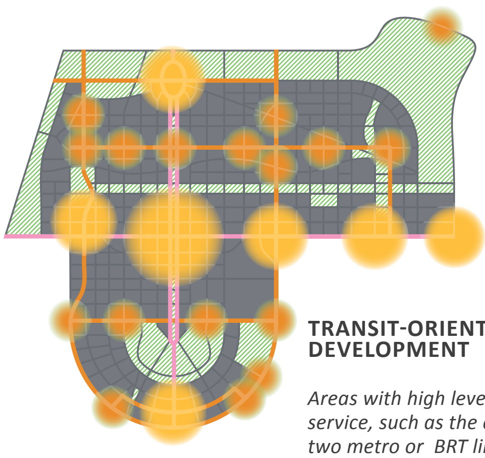
ACCESSIBLE PARKS

Linear greenways, neighborhood parks, and larger community parks are located throughout the plan and are easily reached by car-free streets and quiet local roads.



PAIRED ONE-WAY STREETS AND NARROW ARTERIALS

Through traffic is carried on streets no wider than 45 meters. Higher-volume traffic is diverted onto one-way street pairs, no more than 30 meters wide in each direction to allow easy pedestrian crossing.



TRANSIT-ORIENTED DEVELOPMENT

Areas with high levels of transit service, such as the crossing of two metro or BRT lines, have higher density, more commercial development, and a greater mix of uses.

CASE STUDY 2:
YUELAI ECO-CITY

Yuelai Eco-City is an urban development district in northern Chongqing, China. Chongqing, as a pilot city in China's grand strategy of western development, was the fourth 'special municipality' to be placed under the direct control of the Central Government in 1997. In addition to its political importance, the city plays a key role in the national economy, serving as the financial center of western China, a modern manufacturing center, and the only metropolitan region along the upper reaches of the Yangtze river equipped with water, air, rail and road transportation facilities. It has a current population of thirty million, and is expected to grow in size, adding an additional two to three million by 2025.

The Yuelai site is situated within the lush hills and valleys along the winding Jialing River. Serviced by three proposed Metro stations, and sited between Chongqing's upcoming International Exposition and Horticultural Exposition Centers, the development is poised to become a major population center in the region. In addition, Chongqing leadership has targeted this site to become a regional

Figure 4.13: Existing settlements in the area

Figure 4.14: The site has steep hills with winding roads. One of the entrances to the site is from the Jueyai bridge across the Jialing river.

Figure 4.15: Typical arterial street - Jinxing Avenue, wide and unfriendly for pedestrians

Figure 4.16: Current land use plan for Yuelai, following the Superblock System with wide arterials and un-coordinated land uses.

leader in sustainably conscious development. The future vision for Yuelai Eco-City is one that places a special emphasis on sustainable transportation, infrastructure and energy-efficient uses. In doing so, the term 'Eco-City' will take on a greater meaning, and in reality, a model community for all of China to emulate.

A New Design Vision for Yuelai Eco-City

The current plan for Yuelai suffers from many typical planning problems: large single-use areas, pedestrian-unfriendly superblocks, and development that is un-coordinated with Metro station locations. For Yuelai Eco-City to become an active, vibrant urban community, the plan needs to be redesigned around the pedestrian, bike and transit, not the car - in other words, a design that features the 'Urban Network' with narrow streets and small blocks. This design direction fits perfectly with the 'Five Chongqing' goals being promoted by the local authorities.

Figure 4.17: Proposed land use plan for Yuelai that responds to the challenging terrain and creates walkable neighborhoods based on the 'Urban Network'.

Figure 4.18: Comparison of the 'Superblock Plan' with the proposed 'Urban Network Plan': the proposed plan has lesser land area under roads while yielding a larger amount of built-up area (BUA).

Each of the 'Five Chongqing' principles is incorporated into the new design direction for Yuelai Eco-City:

1. Livable Chongqing: the Eco-City plan creates a series of walkable mixed-use neighborhoods filled with local street life, nearby shops, schools, parks and trails.

2. Smooth Chongqing: the focus of the plan is to enhance transit, walking, and biking, thereby reducing congestion. The highest densities are located at the Metro station, an electric shuttle bus connects throughout the community, and auto-free streets support walking and biking. The major thoroughfare is broken into two human-scaled one way roads enhancing traffic flow while creating pedestrian friendly streetscapes.

3. Forest Chongqing: major streams, valleys, steep hillsides and the Jialing riverfront are preserved as open space complete with parks and trails. Greenbelt areas connect from riverfront to the Chongqing Horticulture Exhibition Park.

4. Safe Chongqing: safety comes in many forms in the Eco-City; small secure blocks rather than superblocks create human-scale communities in which people are more likely to know one another. Active streets with local shops make for safe public spaces and smaller streets help with bike and pedestrian safety.

5. Healthy Chongqing: an active population is a healthy population. More walking not only improves air quality, exercise is critical to personal health. The health of the environment in also enhanced in the Eco-City by building a community that places fewer demands on natural resources and recycles waste.

Figure 4.18: View of Yuelai Eco-City: the street network closely follows existing topography and traditional hillside development patterns.

Design Themes for Yuelai Eco-City

The Yuelai site is unique in its local charm and challenging topography. Therefore, the urban design must go towards a community design closely fitted to its terrain, culture and history. This is the true meaning of ecological design. Therefore, the proposed plan for Yuelai Eco-City is designed to several specific 'Design Themes'. While generally following the 'Five Chongqing' goals, these Design Themes cater specifically to the Yuelai site, creating a true Eco-City. These 'Design Themes' are:

Design Theme 1: Work with the site's natural features

The topography of this site could have been mass graded into a series of relatively flat, buildable sites, but instead the plan was approached with the idea of laying roads and buildings lightly on the land, following the natural landscape. Streets will curve to follow the terrain and the traditional hillside architecture of the area will be used in selected steep areas.

The site plan achieves a connection between the highly valuable river amenity and the new Horticultural Exhibition Park through a series of open space fingers along creek tributaries and through linear parks. Dramatic site features have been preserved and incorporated into the natural open space system, providing lookout points and hillside parks. Open spaces and trails will preserve the land in areas of extreme slopes, riparian corridors and ecologically-sensitive areas.

Design Theme 2: Create a walkable community

Within this steep terrain, creating walkable streets and small blocks presents a tough design challenge. Flatter areas will follow the 'Urban network' with small blocks and narrow streets. 'Auto-free' streets, that allow a mix of pedestrians, bikes and transit systems, but prohibit cars, will play a special role in connecting key community destinations through hilly areas. Some of the site's steepest areas (above 25%) will feature hillside escalators, lined with shops and small businesses, providing a unique pedestrian, hillside experience.

On most roads, particularly those across flat terrain, bike lanes will be provided. A network of dedicated non-auto lanes will permeate the extensive network of public streets and auto-free streets, providing an easy alternative to the car. Public trails will also provide linkages to the natural, hillside areas and the low-lying Jialing riverfront parks, completing the ambitious task of community walkability.

Design Theme 3: Orient development to transit facilities

The two Metro stations in Yuelai Eco-City will become the focus of high-density jobs, services, retail and residential development. At the core of the city is the Ellipse Gateway, an expansive civic plaza with access to the Metro and Bus Terminal; surrounded by public amenities and framed by mixed-use commercial towers and several retail 'main street' retail centers. At the Jinshan Metro station, the existing industrial area will be converted into a mixed-use area, with high-density residential and commercial blocks. An electric shuttle bus will connect residential neighborhoods, providing access to local schools and neighborhood parks.

Figure 4.19: Plan showing slope analysis: the design lays roads and buildings with minimum alteration to the natural landscape.

Figure 4.20: Plan showing pedestrian movement systems: special 'auto-free streets' that prohibit cars, will connect key community destinations.

Figure 4.21: Plan showing the transit network. An electric shuttle bus along a central auto-free street will link a series of neighborhood centers.

Figure 4.22: Development is oriented to transit: plan showing the location of neighborhood centers (above) and transit walksheds (below).

Figure 4.23: The Open Space plan features a wide range of open spaces and civic amenities, varying in scale and purpose, linked by a network of 'auto-free' streets.

A series of Neighborhood Centers will be sprinkled throughout the hillside community, serviced by the electric shuttle bus and local bus lines. These centers will primarily be anchored by schools and small amounts of local-serving retail and within easy walking distance of every home and all bus stop locations.

Design Theme 4: Develop accessible parks and trails

The success of Yuelai Eco-City will hinge on the ability to implement an extensive public parks system, accessible to all. The approximately 340 ha Open Space Plan will be diverse in uses, environments and connectivity. Many green linkages (including riparian trails, people-movers, and linear parks) will provide connections from the low-lying Jialing River area to the adjacent Horticultural Exhibition Center and interior valleys. Active and natural parklands will be developed continuously along the riverfront, with trails and walkways along its 4.6 kilometer frontage. A major recreational area will be developed over and around the sewage treatment plant with sports fields and ball courts provided throughout. Other civic features such as amphitheaters, community gardens, and farmer's markets could be encouraged as destination features along the river's edge.

A series of trails will follow streams up to interior valleys then on to the hillside developed areas with connections to the auto-free streets. These interior parklands will preserve the natural ecology of watersheds and hillsides, while providing places of respite for residents and visitors searching for quiet spaces among the urban environment. Within the developed areas a network of active parks, schools and open space are linked by a variety of auto-free paths and linear park-blocks.

Design Theme 5: Deploy state-of-the-art ecological systems

Reducing auto dependence and its energy, carbon and air quality impacts is foremost in the ecological design for Yuelai Eco-City. However other environmental strategies will also be pursued. Climate-responsive building design will reduce energy and electrical demands as it makes the architecture more appropriate to this region. The use of an electric shuttle bus will replace auto trips and gas consumption. Engineers will investigate the potential for the sewage treatment plant to become a model of 'waste-to-energy' systems by using its methane production in a state-of-the-art electric generation facility. In addition, the waste heat from this plant can be used in a district cooling plant to provide for building needs.

Figure 4.24: A range of building typologies was developed that would meet the density requirements and be also respond to traditional hillside architecture and steep site topography.

Figure 4.25: The two Metro stations will be the focus of high-density residential and commercial development.

Figure 4.26: Some of the site's steepest areas (above 25%) will feature hillside escalators. The pedestrian network will be lined by shops, cafes and other amenities; following traditional hillside architecture of the region.

PHASE ONE DESIGN CONCEPT

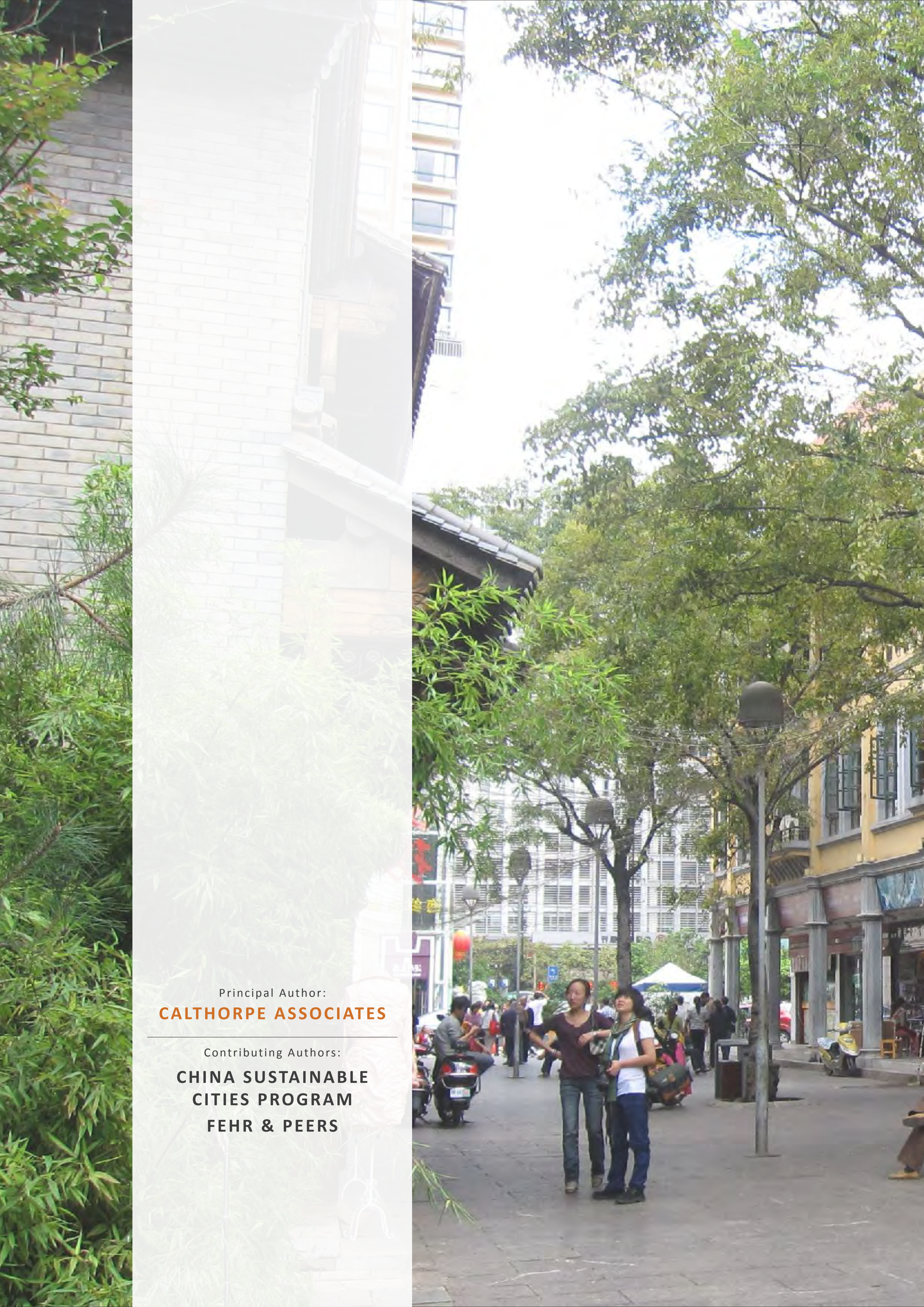
The design for the Phase One area follows the principles guiding the site as a whole; and features 'small-block' zoning and uses the 'Urban Network' as its circulation system. Because of its proximity to high capacity transit infrastructure, this 320 ha site has been designed as the primary Urban Center of Yuelai Eco-City. It features walkable mixed-use neighborhoods with easy access to open spaces , civic amenities and transit facilities.

Phase One is organized around a central open space called the Ellipse Gateway, a grand urban plaza and park that will also connect to the underground Metro station and multi-modal bus terminal. High-density mixed-use towers will frame this space, providing a variety of uses including street-level retail, offices and residences. Radiating from this node, roads, 'auto-free' streets and pedestrian ways will lead to other parts of the site. An electric shuttle bus, acting as a feeder system to the Metro, will provide non-auto access to the high density neighborhoods surrounding the Ellipse Gateway.

Figure 4.27: Yuelai Eco-City Phase One: Illustrative Land Use Plan

Figure 4.28: The Ellipse Gateway at the heart of Phase One, a unique urban plaza and transit node, surrounded by mixed-use commercial towers and featuring a diverse range of public amenities.

Figure 4.28: Rendered view of Phase One, as seen while approaching from the Jialing river.



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