Envisioning a Future City with Autonomous Vehicles

by

Brian Liu

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The evolution and formation of our urban fabric have an inextricable relationship with transportation and urban mobility. The revolution in speed and power of transportation as a result of the automobile in the early 1900's brought about radical changes in how cities were designed and constructed. City streets, previously built for horse-drawn vehicles and foot traffic, were modernized with asphalt and segregated for the sake of speed and convenience. Parking lots, garages and gas stations were carved out of the city fabric to support the population's addiction and dependence on it as the ultimate form of movement. Expansive highways and extensive networks of arterial thoroughfares were put in place as cities began to undergo urban sprawl. As North American cities have evolved and developed around the use of automobiles, the requirements to support its use have become increasingly oppressive to other forms of city life. However, an upcoming revolution in transportation and urban mobility, ushered in by the development of autonomous technology, will present urban designers with new opportunities to re-evaluate the relationship between motorists and the city.

Autonomous technology has the potential to completely redefine the rules regarding the spatial requirements of automobiles and how they operate within the city. It is widely believed that AV (autonomous vehicle) technology will encourage car sharing, shifting the business model from that of predominantly individual car ownership to a service based model, resulting in a significant decrease in number of vehicles on the streets. The efficiency of AVs will also drastically reduce the amount of space required to operate vehicles, allowing for a reduction in traffic congestion and road sizes. Another consequence of AV technology will be the reduction in need for parking, as a result of car-sharing opportunities and the possibility for vehicles to perpetually be in operation. This thesis explores the implications of AVs on the urban fabric and aims to direct urban design towards incorporating AVs towards a more equitable future.

The city of Toronto will be used as a lens for envisioning how a future urban landscape incorporating AVs may take shape. The city currently suffers from immense friction between the overbearing requirements of automotive infrastructure and daily city life. Accidents involving motorists and cyclists are increasingly a problem and efforts to limit the range of the automobile within the city are becoming popular. It is estimated that one third of land in Canadian cities are for cars that aren't even moving, removing land that could otherwise be allocated to additional housing or retail space. Toronto is putting its best foot forward towards a future with AVs though with investment from all levels of government, academia and private entities. The thesis studies the impact of the automobile on a variety of actors and spaces within the city and proposes visions of how the ubiquity of AVs may change the inherent structure of typical typologies in our city today. The work serves as a guideline in how we may design a more equitable city as a result of the opportunities presented from AVs. The advent of autonomous vehicles is inevitable and the visions proposed serve as a porthole into what may become reality within just a couple of decades.

Acknowledgements

I would like to sincerely thank both Rick Andrighetti and Maya Przybylski, for serving as supervisor and committee member throughout my thesis. Their continual enthusiasm and excitement for my research, from start to finish, were critical in pushing me forward. Equally important was their candid feedback, helping to ensure the work I completed was held to a high standard.

I would also like to thank Ali Fard for the early guidance given to me during TRD1 and TRD2. His insights on the formation of cities alongside technology gave me the much needed foundation to focus and ground my research.

I would also like to thank my friends and colleagues in Cambridge without whom I wouldn't be able to endure the stress of architecture school. Sharing in the highs and lows has made these two years much more fun and enjoyable.

A special thanks to my family who has supported me at every turn and always stepped up to the plate to help me. Andrew, this thesis would not have been pushed as far without your insights and knowledge. To my parents, your unwavering support and patience kept me going through all the late nights. Your love and support will always be something I treasure.

To my family, who is always there for me.

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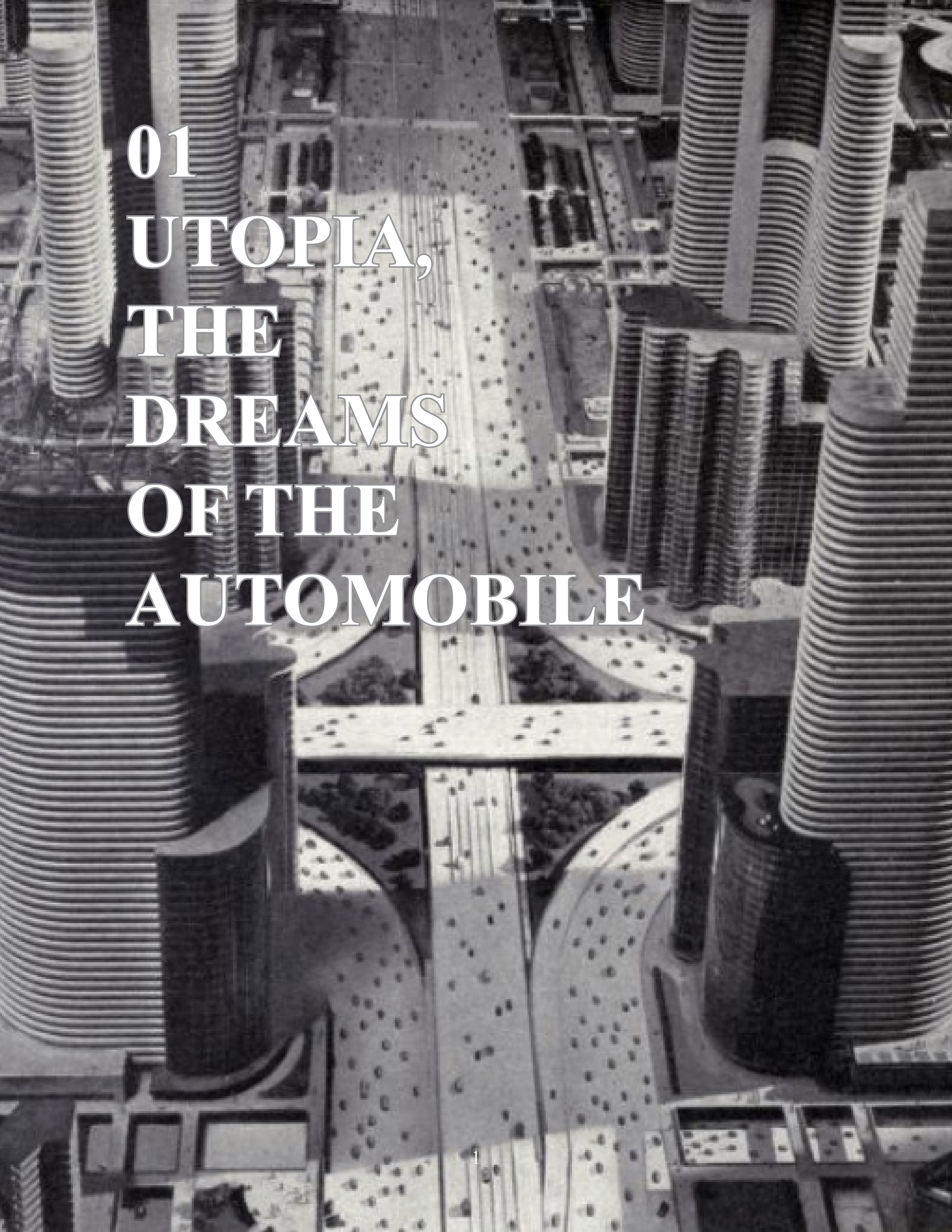
01 UTOPIA, THE DREAMS OF THE AUTOMOBILE



1.1
A Cure-all for Urban Mobility

The technological revolution of the automobile at the beginning of the 20th century brought with it the promise of a new era. Cities and urban planners, plagued by the many social challenges and issues associated with horse powered vehicles, were keen on exploring new transport technologies to improve the prosperity of their people. The rise of numerous new automotive technologies and ultimately the gasoline powered automobile heralded a change in how cities would be formed during the next century.

Horse powered mobility was still dominant at the end of 19th century due to their ubiquity in everyday life, inexpensiveness and ease of use, but it brought with it numerous social and urban challenges. It is estimated that in the US in 1900, there were 24 million horses of which three million were in cities.[1] Horses were an essential driver of industry and were not only used in rural areas for plowing fields, but also

Figure 1.0 - (previous page) Diorama of the Futurama exhibit

Figure 1.1 - A horse drawn trolley in New York City

1 Daniel S. Mills, and Sue M. McDonnell, *The Domestic Horse: The Origins, Development and Management of Its Behaviour.* (Cambridge: Cambridge University Press, 2005.) 25

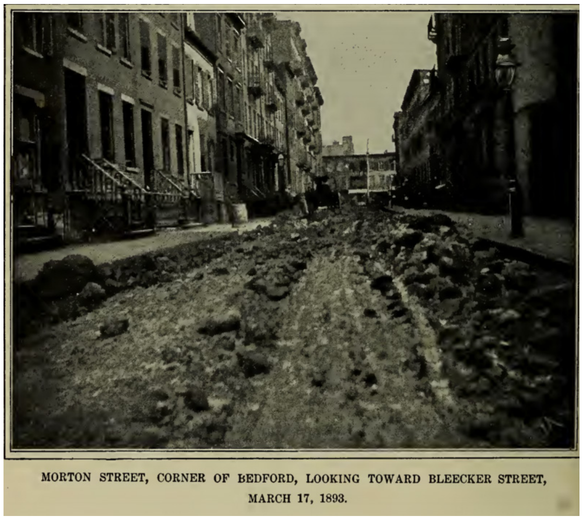


Figure 1.2 - A manure covered New York City street in 1893

Figure 1.3 - A dead horse left for cleaning in New York, 1900-1906

in cities to pull street trolleys, brewery wagons, city vehicles, omnibuses and carriages. Their continued usage was however unsustainable. Joel Tarr, an American history professor, described the situation in his article "Urban Pollution – Many Long Years Ago" as such:

"Sanitary experts in the early part of the twentieth century agreed that the normal city horse produced between fifteen and thirty pounds of manure a day, with the average being something like twenty-two pounds. Ina city like Milwaukee in 1907, for instance, with a human population of 350,000 and a horse population of 12,500, this meant 133 tons of manure a day, for a daily average of nearly three-quarters of a pound of manure for each resident. Or, as health officials in Rochester, New York, calculated in 1900, the fifteen thousand horses in that city produced enough manure in a year to make a pile 175 feet high covering an acre of ground and breeding sixteen billion flies, each one a potential spreader of germs."[2]

The abundant amount of manure threatened to spread diseases such as smallpox, cholera or typhoid, created foul stenches throughout North American cities and strained city resources which had to be allocated for cleaning and collection. The problem was compounded by the short lifespan and abuse of urban horse which frequently died on city streets, leaving behind carcasses to be removed by city staff.[3] The situation was dire enough that the world's first international urban planning conference in New York focused on what had been named the "Great Horse Manure Crisis of 1894", attempting to solve the extravagant amount of manure within urban centres. The conference ended in three days, seven days early, as no one could come up with any solution.[4] It is then not surprising that urban planners looked to other mobility options and technologies to move within cities.

2 Joel A. Tarr, *Urban pollution: many long years ago.* (American Heritage Publishing Company, Incorporated, 1971.)

3 Ibid.

The emergence of numerous forms of motorised transport brought the promise of solving many of the urban issues posed by horse powered transport. Subway and train networks were being built in the larger cities, and carriages powered by steam, electricity and gasoline were being explored. Although initial public resistance to motor vehicles was strong, the benefits of motorised movement were undeniable. Motor vehicles were more efficient than horses at transporting goods, moving at a faster speed and immune to fatigue. They were also much less cumbersome to use. Horses required constant care by grooms and coach men, needing to be saddled, watered, and fed throughout the day, then stored in unappealing stables at night. The most compelling argument at the time for motor vehicles though was the perceived improvement to public health. The fact that the motor vehicle did not leave any waste behind while in operation was a huge boon compared to the disease spreading manure of horses. This would resolve many of the cleaning and disposal issues plaguing the city. It would also eliminate the need for stables, which were also attributed to lower public health. In describing pollution originating from stables, Tarr writes "In the late 1890's insurance company actuaries discovered that employees in livery stables and those living near stables had a higher rate of infectious diseases, such as typhoid fever, than the general public."[5] The shift away from horses also made economical sense for cities. Harold Bolce, writing in Appleton's Magazine in 1908, calculated that New York City could potentially save 100 million dollars from the elimination of diseases created by horse manure, reduced need for street cleaning, decrease in traffic congestion, and increase in speed of transporting goods.[6] The transition towards motor vehicles quickly took

Figure 1.4 - The last days of horse-cars in Manhattan

Figure 1.5 - Newspaper ad for Winton Motor Carriage in 1898

4 David Doochin, "The First Global Urban Planning Conference Was Mostly About Manure." (Atlas Obscura. October 01, 2016.) https://www.atlasobscura.com/articles/the-first-global-urban-planning-conference-was-mostly-about-manure.

5 Tarr. *Urban Pollution.*

6 Ibid.

Figure 1.6 - Newspaper ad for "Rapid" comparing its efficiency over horse powered transport

hold towards the end of the first decade of the 20th century and what seemed like a solution to every issue of urban mobility at the time began to take shape.

Ultimately gasoline vehicles became the mobility option of choice and cities around North America began transitioning their urban fabric towards facilitating its use. At the onset, many of the promised benefits were realized. City streets were cleaner with the removal of horses and manure. Community health was improved as particle pollution from ground-up manure and the number of flies was greatly reduced. Transport was cheaper, faster and more efficient resulting in reduced congestion and increased mobility.[7] Be that as it may, what had seemed like a technological cure-all for urban mobility was short sighted in its utopian promise. As we know now, the adoption of the car has lead to other types of pollution such as noise and air pollution. While the consequences may be different from the diseases resulting from horse manure, pollutants from cars have wreaked havoc on our environment and respiratory health. Although the prowess of automobiles has allowed us to travel faster and farther within the urban city, it has also resulted in vast urban sprawl and congestion. It is thus important to remember the circumstances and consequences regarding this technological revolution in mobility at the beginning of the 20th century when considering potential technological advances promising to remedy the issues of mobility today. What may seem like a revolutionary technological solution to our current urban woes could result in more serious headaches in the future.

Figure 1.7 - 1923 Ford Model T

Figure 1.8 - Cars line up for the Holland Tunnel, 1927

6 Ibid.

7 Ibid.

Figure 1.9 - New York City's Fifth Avenue on Easter morning 1900 bustling with horse-drawn traffic

Figure 1.10 - Fifth Avenue on Easter morning 1913

1.2
The Fetishization of the Automobile

The promise of unparalleled speed and power, as a result of the automobile compared to horse powered mobility, was also a catalyst in galvanizing people's imaginations of future cities. Across every level of society, from artists to industrialists, people were enamored by its potential impact on future urban life. For instance, the automobile was a prime focus for the artistic and social movement of Futurism during the early 20th century. The relatively new technology stood as an exemplary symbol of many of the movement's core concepts: speed, violence, machinery, and industry. Filippo Tommaso Marinetti, an Italian poet and one of the founding members of the Futurism movement, specifically mentions the wonders of the car in an article of his Manifesto of Futurism published in 1909:

Figure 1.11 - *Dynanism of a Car* by futurist painter Luigi Russolo

"4. We affirm that the world's magnificence has been enriched by a new beauty: the beauty of speed. A racing car whose hood is adorned with great pipes, like serpents of explosive breath—a roaring car that seems to ride on grapeshot is more beautiful than the Victory of Samothrace."[8]

Marinetti and his Futurist colleagues'

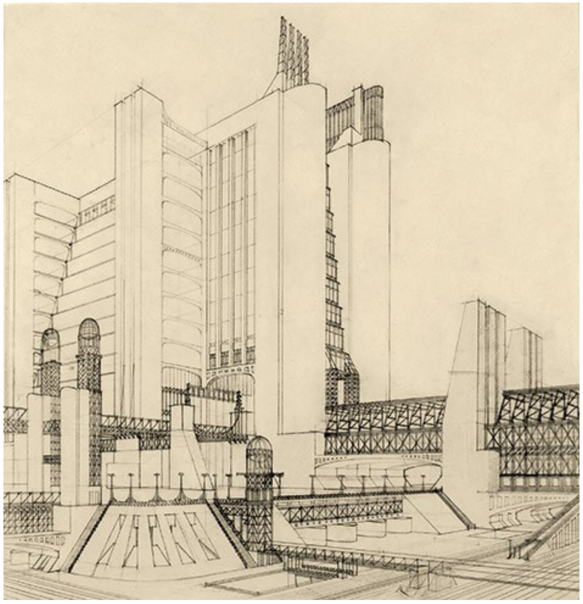


Figure 1.12 - Drawing of a Futurist city by Antonio Sant'Elia

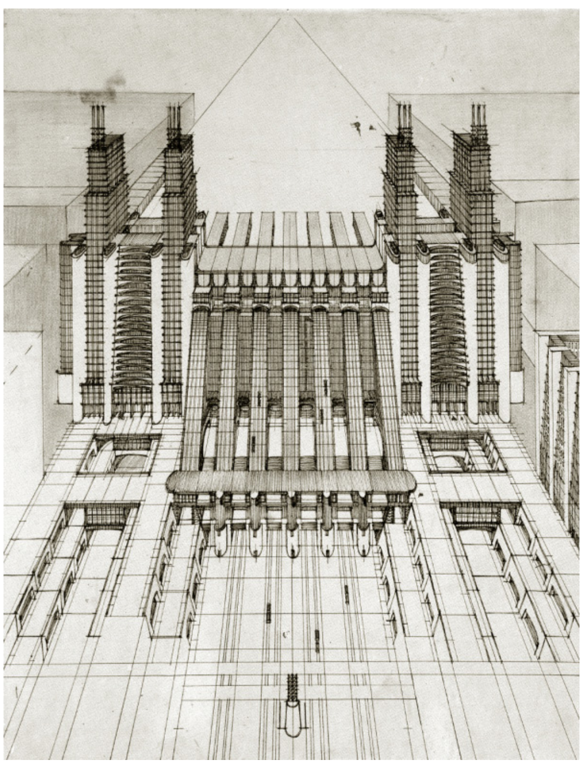


Figure 1.13 - Drawing of a train and airplane station by Antonio Sant'Elia

obsession with the speed and power of the car aptly encapsulated the excitement of the general populace at the time and further pushed the narrative of a technological utopia. The Futurist infatuation with technology was perpetuated later on as well by Antonio Sant'Elia and his influential drawings, depicting an urban utopia closely linked to ever developing technological revolutions. In his *Manifesto of Futurist Architecture*, he reinforces the concept of a technological utopia by firmly stating his abhorrence of "All classical architecture, solemn, hieratic, scenographic, decorative, monumental, pretty and pleasing" and promoting the need for the Futurist city to be "agile, mobile and dynamic in every detail".[9] The movement's first and perhaps most famous realization into architecture came in 1923 with the opening of the Lingotto factory designed by Giacomo Mattè-Trucco. The factory, which functionally produced different models of Fiat Cars, was an embodiment of the philosophies of Futurism and served as a monument to the greatness of the automobile. It showcased the wondrous side of mass production, through a series of interconnecting floors that formed a spiral assembly line weaving up the building, and the power of the automobile, through its banked concrete test track occupying the whole roof of the building.[10] The work of the Futurist movement would continue to be influential later in the 20th century and be a testament to the ability of the automobile to galvanize people's vision of the future.

8 Filippo Tommaso Marinetti, "The futurist manifesto." (Le Figaro February 20, 1909), 39-44.

9 Antonio Sant'Elia, *Manifesto of Futurist Architecture*. 1914.

10 Tom Joslin, "Fiat's Roof Top Test Track." (Jalopnik. June 18, 2013.) https://jalopnik.com/5714628/fiats-roof-top-test-track.

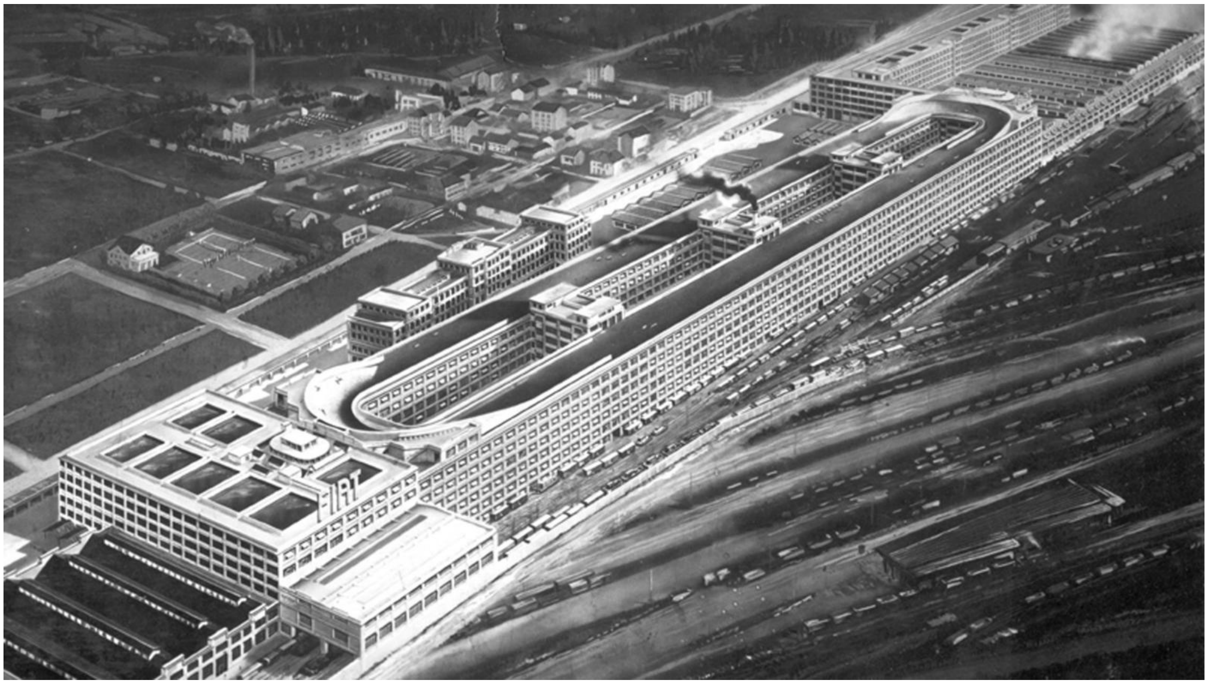


Figure 1.14 - Lingotto factory in Turin

Figure 1.15- Spiral assembly line of the Lingotto Factory

Figure 1.16 - Test track on the roof of the Lingotto Factory

Figure 1.17 - Banked turns on the test track

In addition to the automobile's speed and power, its prospective proliferation and ubiquity were also the subject of a lot of focus as well and generated both utopian and dystopian imaginations of the future. The potential ramifications of an automobile-centric city were highlighted especially in popular mass media. One example is Fritz Lang's 1927 silent film *Metropolis*, which presented to its audience the dangerous duality of technology: its potential to inflict a dystopian future for one class of citizens and create a utopian future for another. The film begins by painting a bleak picture of technology's effect on society, the dehumanisation of a lower working class of citizens as nothing more than cogs in a living machine that is the city. The film then immediately contrasts this dystopia with a utopian depiction, filled with gardens, stadiums and libraries connected through aerial highways, streams of moving cars, and airplanes flying between building, but solely reserved for privileged upper-class citizens.[11] These scenes from *Metropolis* presented a grim reminder of the realities that could occur with the irresponsible implementation of technology within society and are very much still applicable when considering any new technology today.

The question of equality and humanity in a technology enabled city of the future was examined again in David Butler's 1930 film *Just Imagine* in which automotive technology was again a focus. The setting of the film examines the technological advancements in mobility in New York from 1880 to 1930, a transition from horse powered mobility to motorised movement, and then projects what a future New York in 1980 would look like. In another dystopian prediction, Butler argues in the opening minutes of the film that the increased speed of automobiles over horses contributed in dehumanising society through the elimination of everyday interactions between people. The film takes the same time span of 50 years and then challenges the audience to "just imagine the New York of 1980… when everyone has a number instead of a name" as if

Figure 1.18 - Depiction of the working class in Metropolis

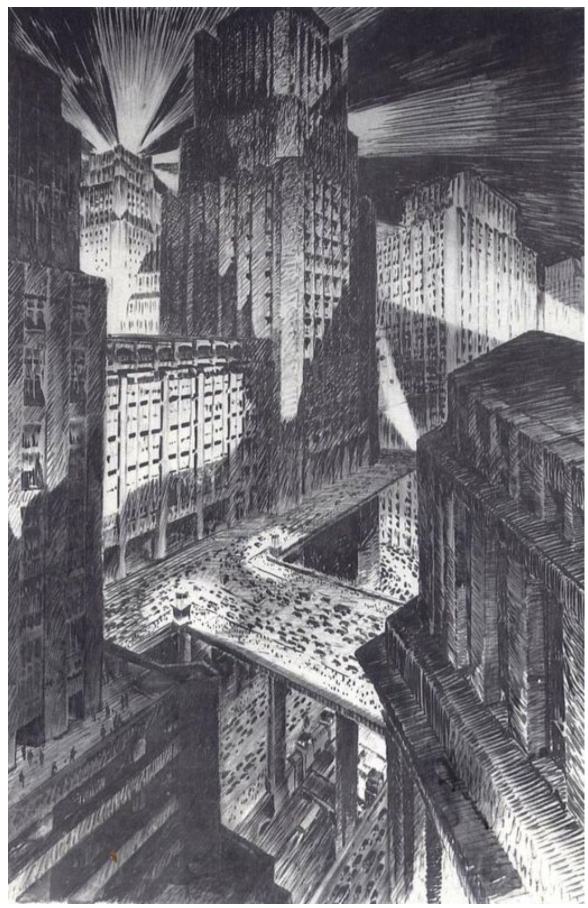


Figure 1.19 - Sketch by Otto Hunte of the city of Metropolis

11 *Metropolis*. Directed by Fritz Lang. Ufa, 1927.

Figure 1.20 - The utopia of Metropolis enabled by the power of the automobile

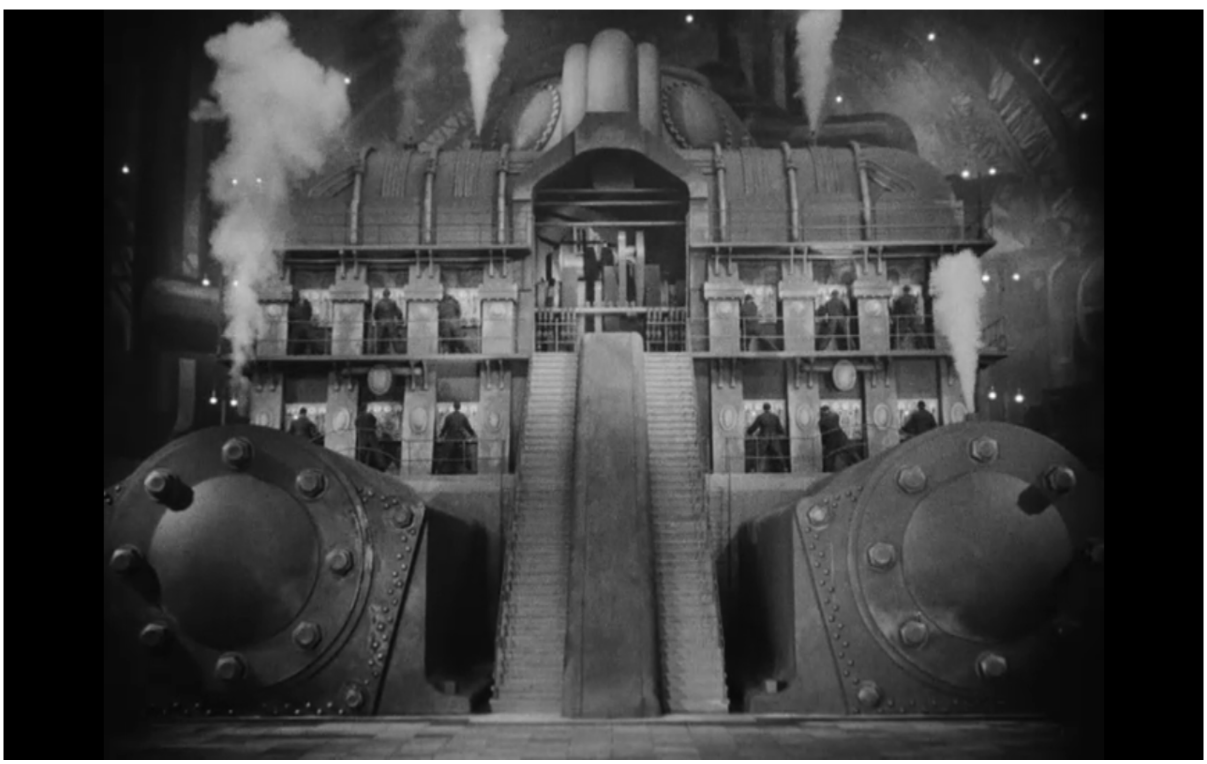


Figure 1.21 - The working class depicted as cogs in te machine of the city

another leap in mobility will further dehumanise society.[12] Although the dystopian visions of Metropolis and Just Imagine! were exaggerated in nature, they served an important role in influencing urban planners to fully consider the consequences when implementing new technologies within cities, especially those related to mobility. These warnings are once again relevant as we approach another technological revolution in mobility akin to the introduction of the automobile at the beginning of the 20th century. How will the future city balance the opportunities for a technological utopia against the need for a humane society?

Figure 1.22 - Poster for Just Imagine!

Figure 1.23 - Depiction of 1880 New York highlighting horse traffic

Figure 1.24 - Depiction of 1930 New York filled with bustling automobiles

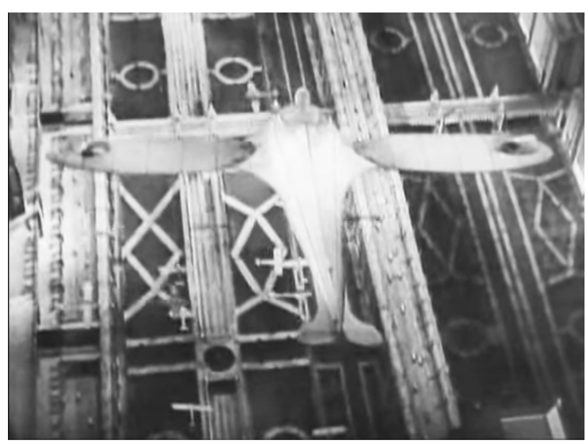
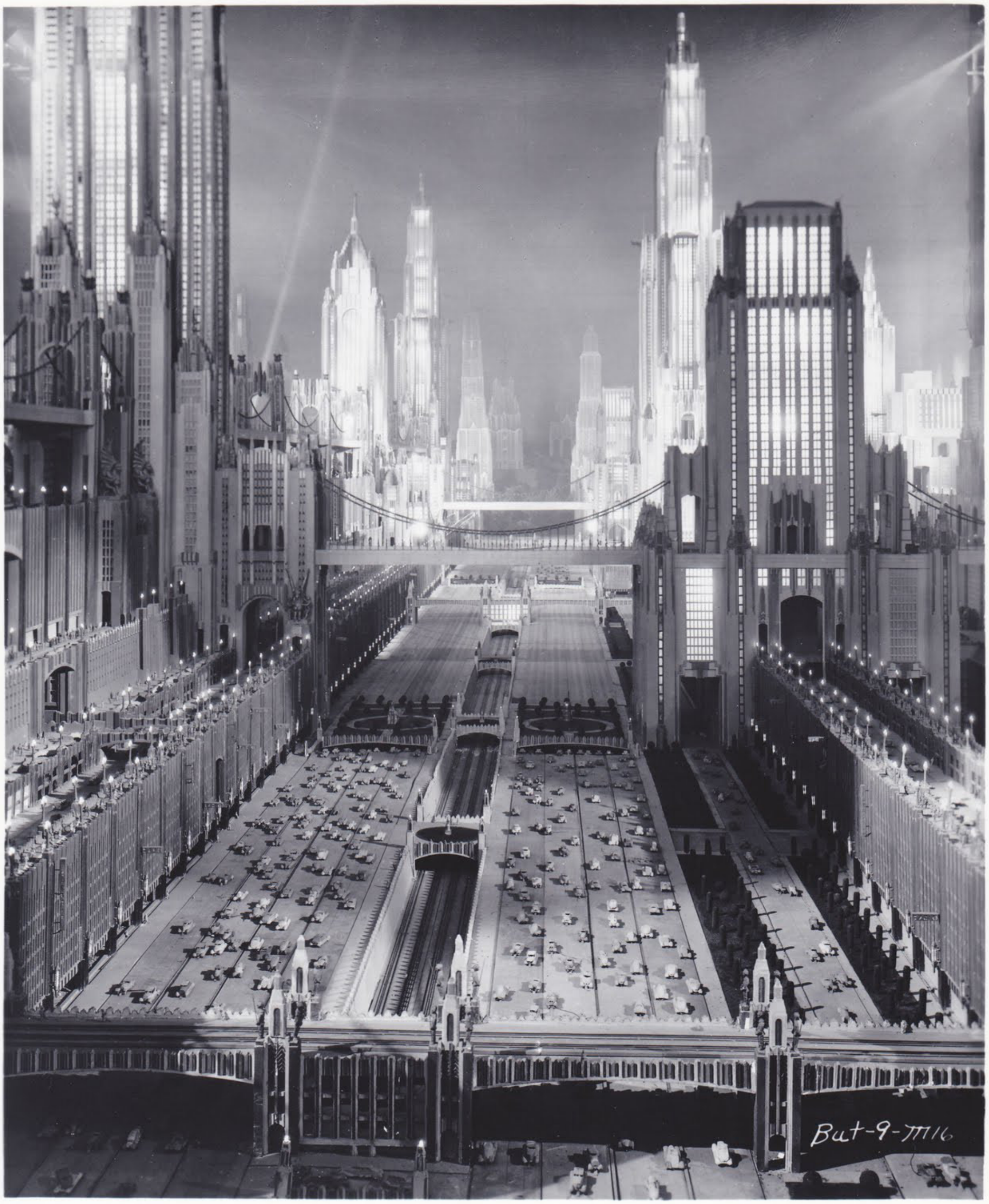


Figure 1.25 - Depiction of 1980 New York filled with air traffic

12 *Just Imagine!*. Directed by David Butler. Fox Film Corporation, 1930.



A Scene from the Fox Picture
"JUST IMAGINE"

Figure 1.26 - A scene displaying the fetishization of the automobile

1.3
Architectural Utopias of the Future

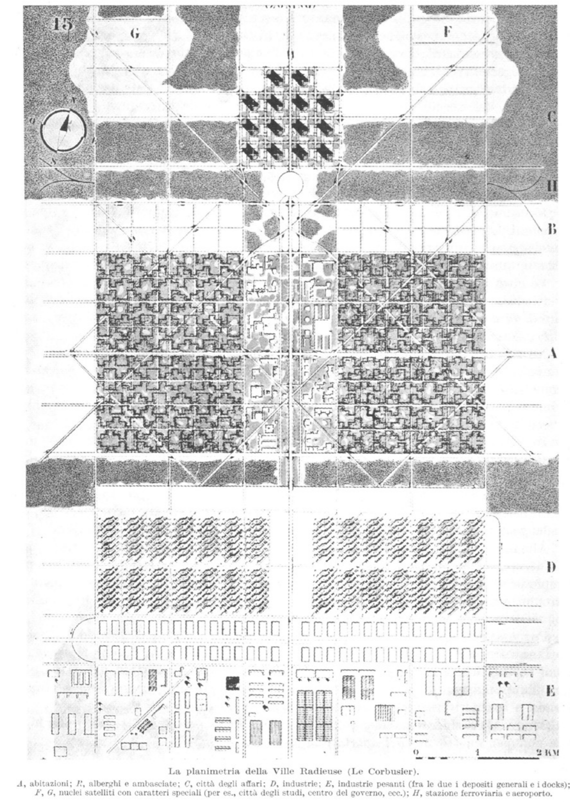


Figure 1.27 - Plan View of Ville Radieuse

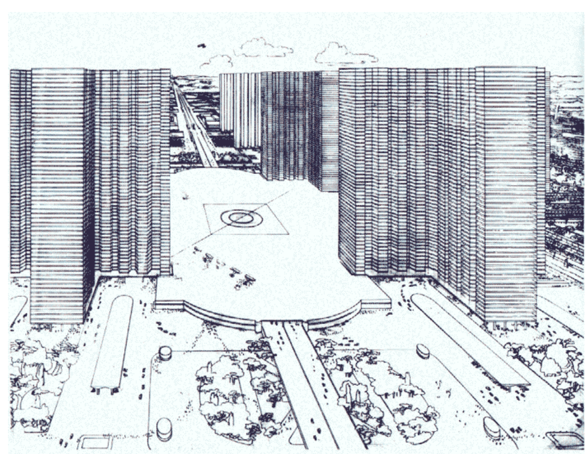


Figure 1.28 - A highway going through the city

The rising popularity of automobiles and its effect on the structure of cities would also spur architects and urban planners to propose visions of a future utopian city. Two of the most well-known architects, Frank Lloyd Wright and Le Corbusier, each envisioned vastly different urban responses that would begin to form the architectural response to the novel technology. Although each scenario would eventually be accepted as flawed in one way or another, understanding the grounding of each proposal and the logic behind the design choices is important as we transition into another phase of innovation in mobility.

Le Corbusier would take advantage of the range of the automobile in his ideal city, the Ville Radieuse, an orderly and strictly organized metropolis of the future. Leveraging the ability of a city's residents to travel quickly utilizing a car, the Ville Radieuse implemented strict zoning restrictions as the primary method to better society. The city would be sectioned by function, commercial, business, entertainment and residential areas, reliant on an extensive

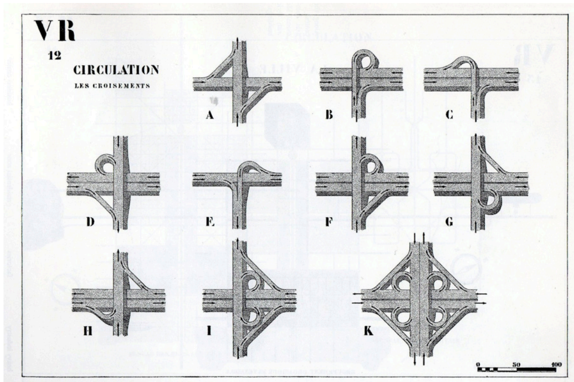


Figure 1.29 - Design of intersections alllowing only right turns

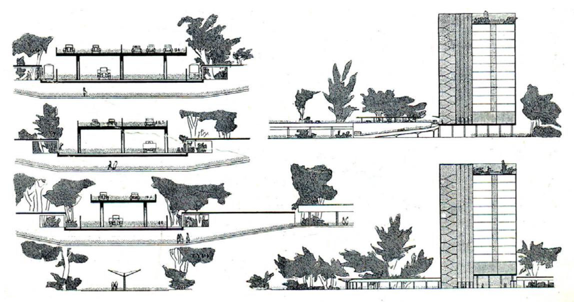


Figure 1.30 - Road Sections in Ville Radieuse

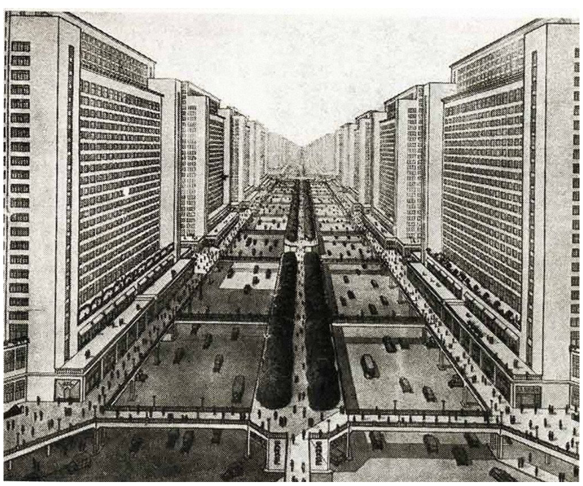


Figure 1.31 - An illustration of a highway in Ville Radieuse

network of highways to connect them all.[13] Although Le Corbusier's design intentions were noble, the master plan suffered from the key criticism described in Metropolis: the potential for technology to dehumanise. The prefabricated and identical buildings arranged on a Cartesian grid into various pre-defined zones, which amusingly bore a close resemblance to the dystopian machine-like city in Metropolis, eliminated any notion of individuality. The top-down nature of the design disallowed any flexibility in function within zones nor provided any space for pedestrian encounters. Space within the city prioritized wide stretches of highways, leaving undesirable gaps between buildings that would remain barren. Every aspect of the master plan seemed to be designed around the features of the automobile and lacked any attention to the human scale. Notwithstanding, Le Corbusier would go on to spread the utopian doctrine in his Ville Radieuse through CIAM meetings as well as through a book by the same name influencing planners for the next few decades. Its principles would finally get realized in 1949 when Le Corbusier was offered the chance to design India's first planned city Chandigarh. His principles would also heavily influence Lúcio Costa and Oscar Niemeye's master plan for Brazil's capital, Brasília. These planned cities now suffer from many of the dehumanising characteristics of Modernist urban planning and have become lessons from which to learn. They are a stark reminder of the dangers of focusing urban design towards an emerging technology without paying attention to the needs and habits of the people that inhabit the city.

13 Gili Merin. "AD Classics: Ville Radieuse / Le Corbusier." (ArchDaily. August 11, 2013) https://www.archdaily.com/411878/ad-classics-ville-radieuse-le-corbusier.

On the other side of the spectrum, Frank Lloyd Wright saw the potential of the automobile as an opportunity to decentralize the city and would present his concept of utopia, Broadacre City, in his book The Disappearing City. Within automobiles and its associated infrastructure, Wright saw the opportunity for a happier and liberating life, writing:

"Young as the highway system is, however, it requires but little imagination to see in the great highway and see in the power of all these new resources of machines and materials a new physical release of human activity within reach of everyone… not only as adventure and romance with nature but a basis for safer, saner, less anxious life for a sane and dignified free people. A longer, happier life waits, naturally, upon this change sense of a changed space relationship."[14]

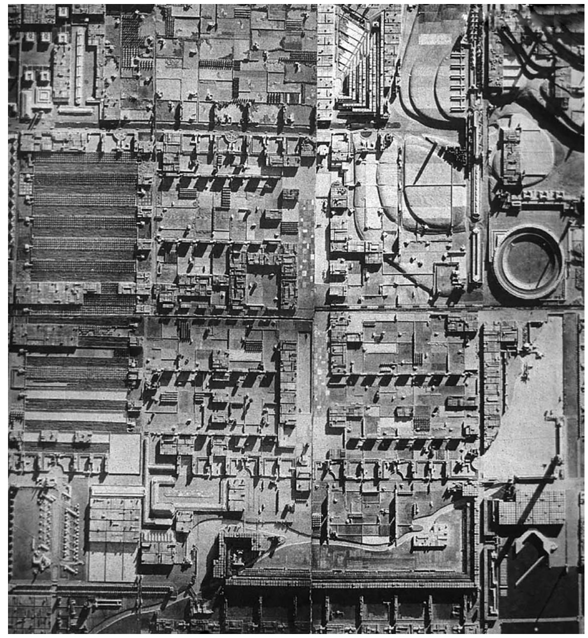


Figure 1.32 - Plan view of the Broadacre City Model

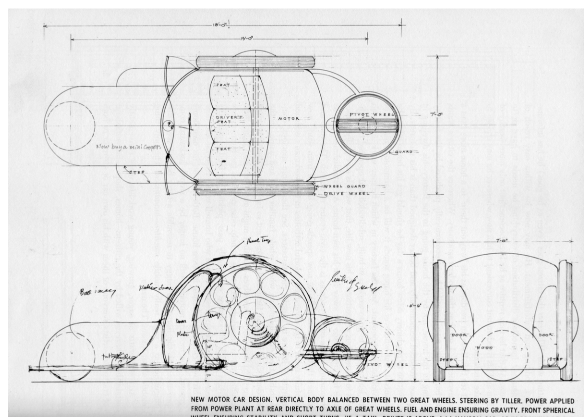


Figure 1.33 - Future motor car design in Broadacre

The urban plan capitalizes on the convenience of the automobile, as well as other new technologies such as refrigeration and the radio, to allow the population to disperse across large swathes of land while still staying connected to public realm. The utility of these technologies are leveraged to enable Broadacre City's core concept: the allocation of one hectare of land per family unit.[15] Based around this concept, Wright then projects, primarily through prospective future technology, how various services will function. He touches on numerous building typologies, from power stations, farms, factories, hotels, hospitals to churches, theatres and schools, all with the mindset that new technologies will revolutionize each and every one of them.[16] In describing the structure and organization of Broadacre, Wright explains, "All of these units so arranged and so integrated that each citizen of the future will have all forms of production, distribution, self improvement, enjoyment, within a radius of a hundred and fifty miles of his

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14 Frank Lloyd Wright. *The Disappearing City.* (WF Payson, 1932), 44.

15 Ibid. 43.

16 Ibid. 58-79.

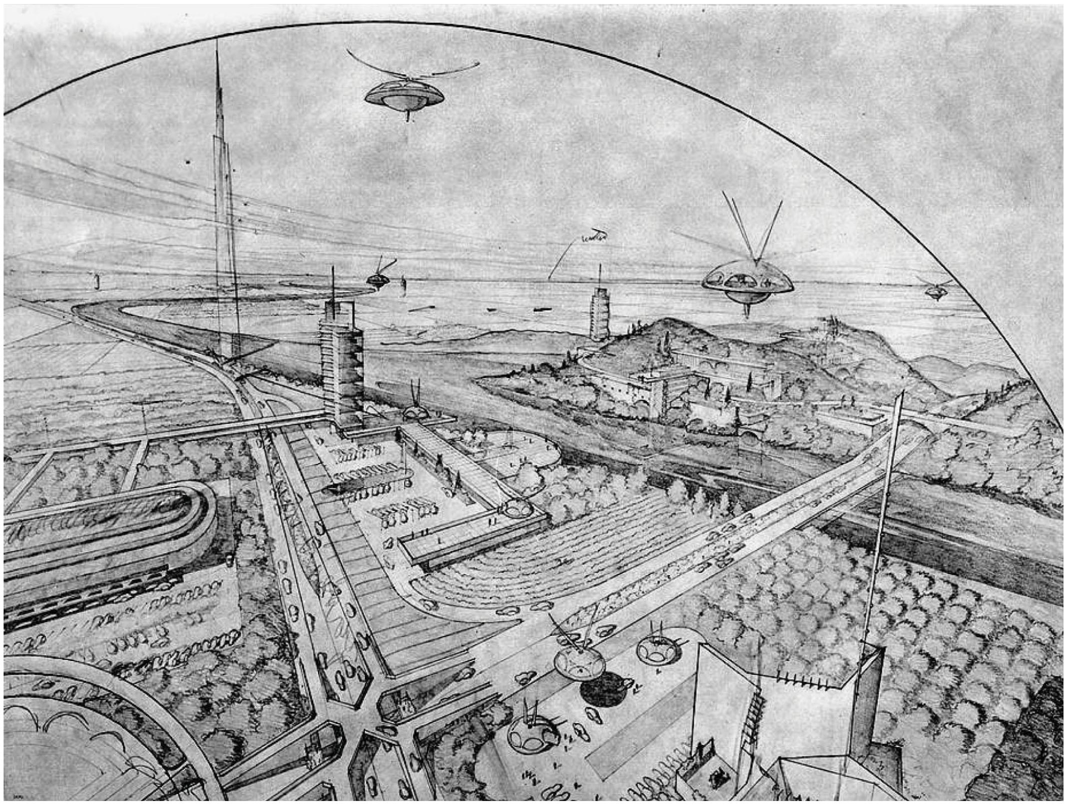


Figure 1.34 - Mobility within Broadacre City

Figure 1.35 - Division within Broadacre City

home now easily and speedily available by means of his car or his plane."[17] As a result, particular focus is placed on maximizing the efficiency of the automobile and mobility, with detailed descriptions of maintenance stations, road systems and gas stations.[18] Wright elucidates in an article in the *Architectural Record*,

"The traffic problem has been given special attention, as the more mobilization is made a comfort and a facility the sooner will Broadacres arrive. Every Broadacre citizen has his own car. Multiple-lane highways make travel safe and enjoyable. There are no grade crossings nor left turns on grade. The road system and construction is such that no signals nor any lamp-posts need be seen. No ditches are alongside the roads. No curbs either."[19]

We can thus see that, in the same vein as Le Corbusier's and his Ville Radieuse, Wright also places a lot of emphasis on the facilitation of automobiles in his utopia. As a result, Wright falls into the same pitfalls. Broadacre city lacks even fewer opportunities for chance encounters or communal interaction compared to Ville Radieuse. The isolation of individual families to separate private acres of land, which Wright justifies for an individualistic future, goes against the very social nature and needs of human beings. Moreover, when Wright tries to address the issue of community and interpersonal activities in his proposal, it is always through the requirement of a technology, such as the radio or automobile, which imposes additional hurdles. To illustrate, when explaining Broadacres proposed communal centres, he writes: "Of course such centers would be features of every new city and each would be an automobile-objective situated near some major highway".[20] The absolute prerequisite and dependence on a technology, in this case

17 Ibid. *44.*

18 Ibid. 50-51.

19 Frank Lloyd Wright. "Broadacre City: A new community plan." (Architectural Record 77, no. 4, 1935), 243-254.

20 Wright. *The Disappearing City*. 74.

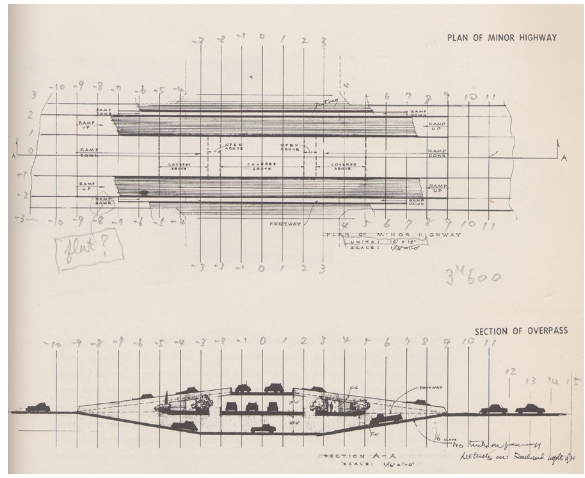


Figure 1.36 - Plan and section of a minor highway in Broadacre City

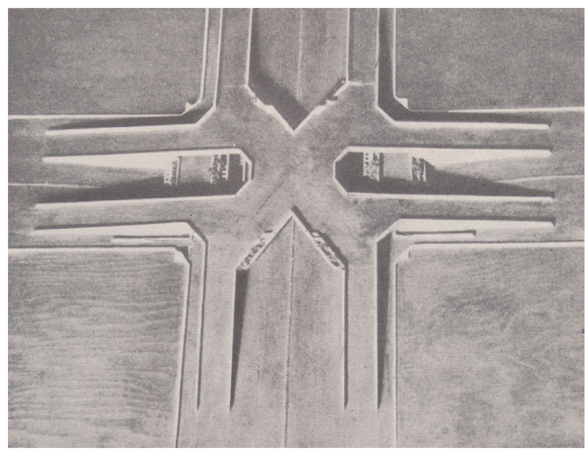


Figure 1.37 - Intersection of highways

the automobile, for any and all activity not only further disconnects people from one another, but also threatens to further dehumanize society.

As is seen in both Le Corbusier's Ville Radieuse and Frank Lloyd Wright's Broadacre City, the unprecedented opportunities made available by new technologies galvanize architects and urban planners to envision idealistic futures. Yet these same technologies also possess the capability to spiral us into a dystopian future if implemented improperly. Revolutionary technologies such as the automobile are a double-edged sword, requiring equal attention to be paid to both opportunity and danger. Consequently, designers such as architects and urban thinkers must tread carefully, ensuring these technologies serve to enhance our humanity rather than transform us into cyborgs.

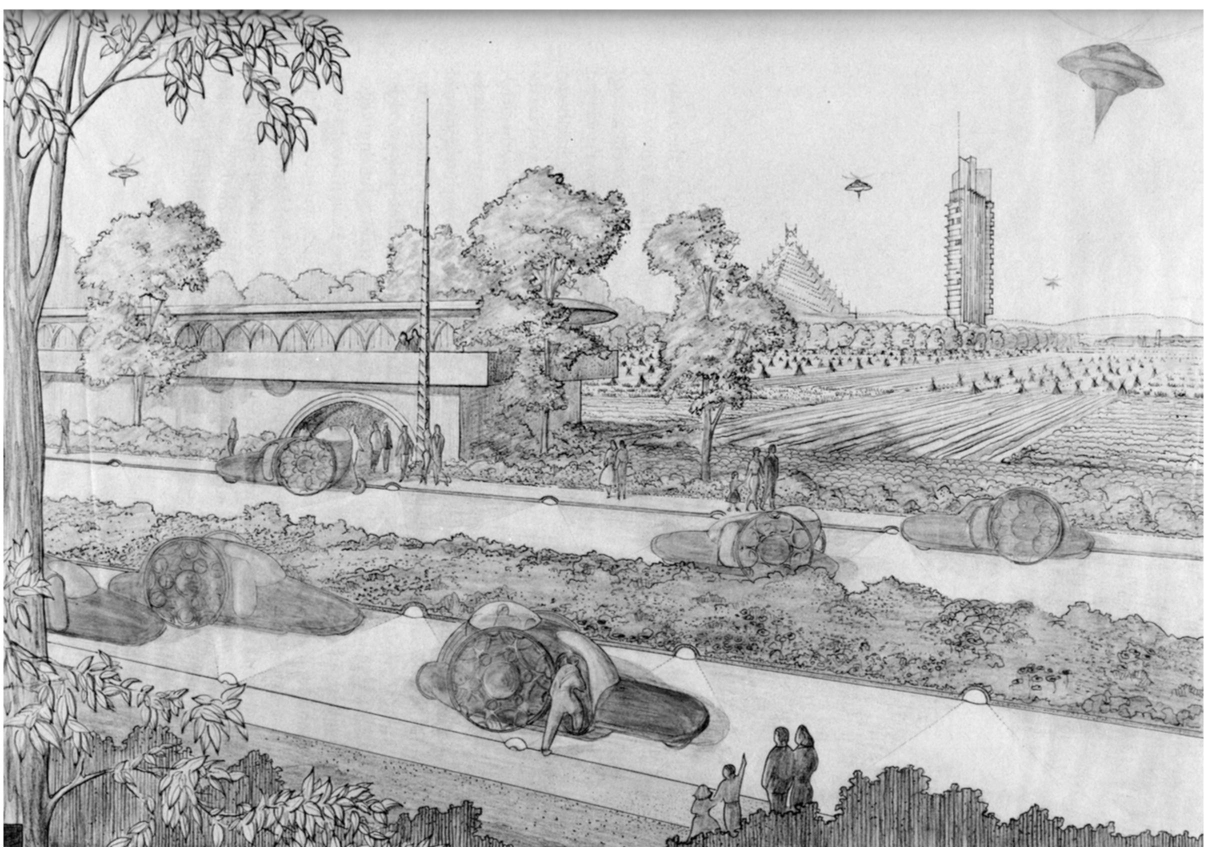
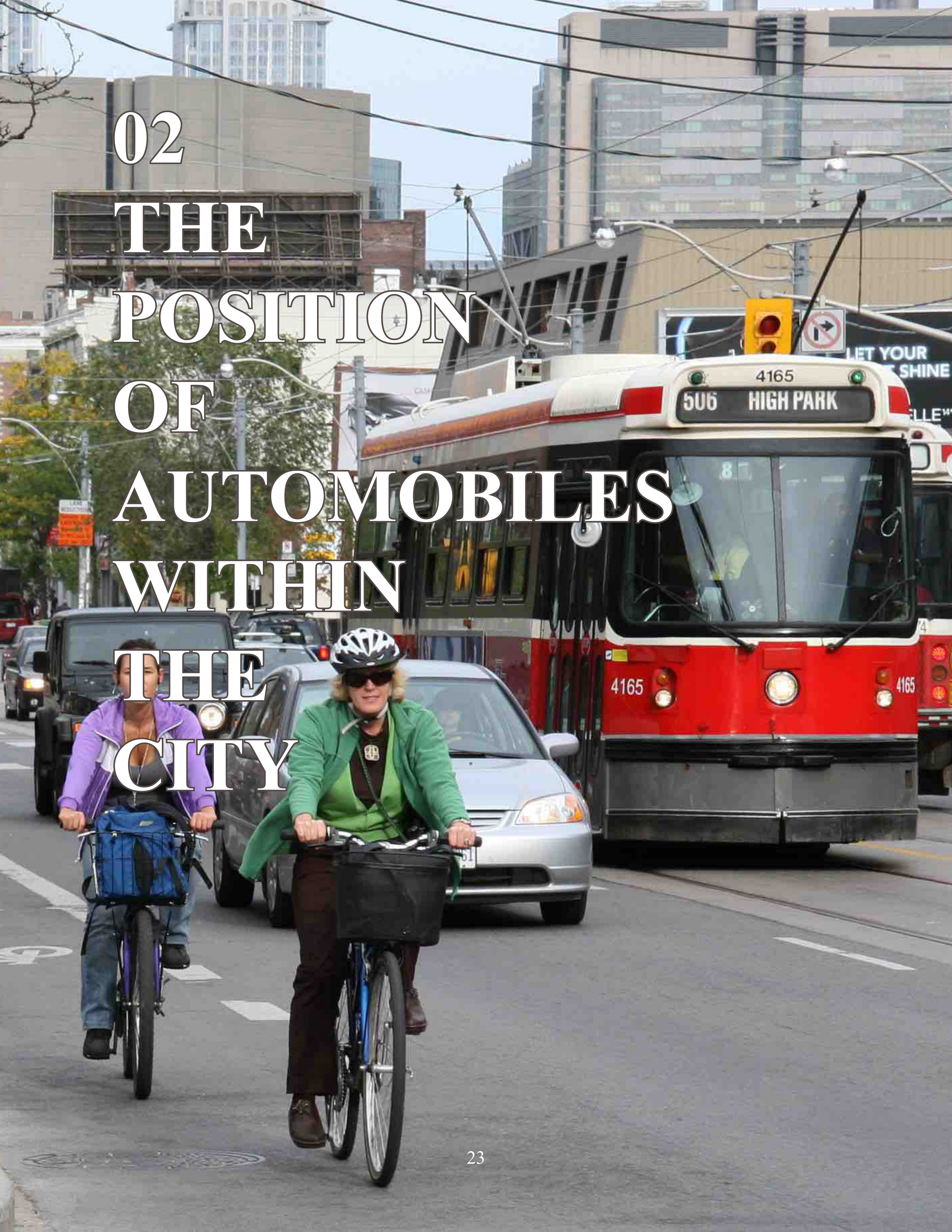


Figure 1.38 - A typical road in Broadacre City

02 THE POSITION OF AUTOMOBILES WITHIN THE CITY



2.1
Post-Modernism

As cities began to develop around the car in the latter half of the 20th century according to modernist principles of top-down, comprehensive and rational planning, its failures and weaknesses became increasingly apparent. At the centre of many of the problems were the affordances allowed for the sake of automotive efficiency. Municipal planning practices promoted automotive dependency, often at the expense of other forms of mobility and sense of community. Two major forces within urban planning would cement the necessity of automobiles in North American living: the establishment of suburban living and the adherence of city planners to Modernist principles. The frictions generated by the ubiquity of automobiles within cities would eventually ignite backlash from urban activists and provoke a change of heart towards the freedom of motorised transport

The conception of suburbs and their pervasiveness around every major city in North America would create a dependency on the automobile. Its rise in popularity took place primarily after World War 2, serving to accommodate the influx of returning veterans with the promise of a luxurious life and a place to raise a family. The lack of residential construction during the war, along with the massive boom in

Figure 2.0 - (previous page) A complete street in Toronto

Figure 2.1 - Levittown, New York

Figure 2.1 - Ad for Levittown targeted towards veterans

Figure 2.3 - Mass production of Levittown suburb in Pennsylvania

population in the US due to returning veterans, immigration and the baby boom had created a critical shortage of housing right after the war. As a response, the US government implemented four key pieces of legislation to solve the crisis: the Servicemen's Readjustment Act, the Veterans' Emergency Housing Act, the Price Control Extension Act of 1946 and the Housing and Rent Act of 1947.[1] These laws created enormous incentives for the creation of new homes as well as increased accessibility to new housing. Incentives included government-guaranteed mortgages, low interest rates, manufacturer subsidies for building materials, price fixing of newly constructed homes, rent control and numerous other allowances for veterans.[2] These series of incentives, along with the popularization of the traditional family model, desire for a luxurious family life and the standardization of homes would create the perfect formula for a massive boom in suburb construction. Government statistics of new housing units at the time show an increase from 326,000 new homes in 1945 to 1 million new homes in 1946 and a continued average of around 1.5 million new homes per year till the end of the 1960s.[3] The housing situation followed a similar trend in Canada with the signing of the National Housing Act of 1944 which helped with the financing of new homes.[4] As more and more of the population transitioned into suburban life, the dependence and addiction of North American cities to the convenience and power of the automobile grew. This dependence would then in turn spur massive investment into automotive infrastructure, such as the Federal-Aid Highway Act of 1956, and cement the automobile as inextricable from the North American way of life.

1 Miles L. Colean. "The Impact of Government on Real Estate Finance in the United States." (NBER Books,1950), 107

2 Ibid. 107-110.

3 U.S. Department of Commerce "Revised Estimates of New Nonfarm Housing Units Started, 1945–1958" (*Construction Reports* 1964). http://www.michaelcarliner.com/Arch-Data.html

4 "Housing." (Monthly Labor Review 60, no. 3 1945), 585-89.

Modernist city planning in the years following the war also played a crucial role in the proliferation and ubiquity of automobiles. The increased mobility of the population, as a result of access to cheap automobiles, enabled city planners to implement zoning policies which shifted the scale of urban design towards cars rather than the pedestrian.[5] What would ensue would be the segregation of residential developments from commercial, institutional and recreational developments at the scale of the automobile rather than the pedestrian. No longer would you be able to effectively walk from where you lived to where you worked, shopped and played. The speed and power of the automobile would be depended on as the sole connection between these areas. The shift in urban scale and consequent planning would manifest itself through the complete destruction of existing mixed-use neighbourhoods into organized blocks of developments as well as the rapid construction of networks of urban expressways connecting the rapidly sprawling city. Perhaps the most ardent champion of the urban role of the automobile at the time was Robert Moses, an influential urban planner overseeing New York. His advocation for and building of extensive networks of expressways throughout New York, often at the cost of the destruction of entire neighbourhoods, would epitomize the shift in urban focus and scale towards the automobile from the 1930s through to the 1960s.[6] This wanton destruction of the complex fabric of the city would generate enormous backlash and resentment from city residents and, with their champion Jane Jacobs and her book *The Death and Life of Great American Cities*, signal the end of the idolization of the car as an utopian technology by the end of the 1960s.

Figure 2.4 - Protests in New York against expressways

5 Peter Hall. *Cities of Tomorrow: An Intellectual History of Urban Planning and Design in the Twentieth Century*. (Chicester, England: John Wiley & Sons, 2014.)

6 Hilary Ballon, and Kenneth T. Jackson, eds. *Robert Moses and the modern city: The transformation of New York*. (New York, New York, USA: WW Norton & Company, 2007.)

Figure 2.5 - Students protesting the Spadina Expressway

Figure 2.6 - Jane Jacobs at a demonstration against the proposed Lower Manhattan Expressway

2.2
The War Against the Car

As the ubiquity and dependency on automobiles for urban life revealed its failings, urban design movements championing walkability and the pedestrian scale skyrocketed in popularity. The ideas of the New Urbanism urban design movement gained traction at the end of the 20th century, promoting walkable residential neighbourhoods containing a variety of housing types as well as plentiful amounts of parks, playgrounds and plazas, all easily accessible by a network of pedestrian friendly streets. In terms of the relationship with the automobile, New Urbanists viewed it as something to be accommodated but to be discouraged through urban design strategies. Pedestrian friendly design was paramount, to be promoted through abundant amounts of shading, wide sidewalks and plentiful amounts of interaction while infrastructure related to the use of vehicles such as garages were to be hidden at the rear of buildings or in alleyways.[7] The shift away from automobiles would eventually manifest itself into the current prevailing "Smart

Figure 2.7 - Protests in New York against expressways

7 Congress for the New Urbanism. "Charter of the new urbanism." (Bulletin of Science, Technology & Society 20, no. 4 2000), 339-341.

Figure 2.8 - An example of a New Urbanist masterplan. Seaside, Florida

Figure 2.9 - An example of a building around a central square

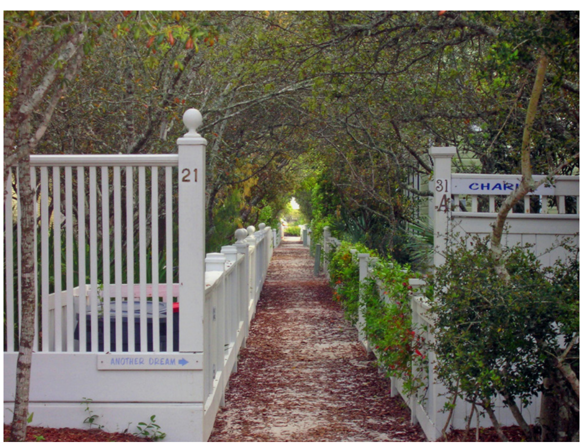


Figure 2.10 - Pedestrian walkway behind houses in Seaside, Florida

Growth" urban design movement, which outlines various policies focusing on creating walkable urban cores as a way to manage growth.[8] Smart Growth policies have especially gained momentum in North American urban design as a solution for automobile dependency. South of the 49th parallel, the largest organization of professional planners, the American Planning Association published *Growing Smart Legislative Guidebook: Model Statutes for Planning and the Management of Change* in 1998 as a framework for "the next generation of model planning and zoning legislation for the United States". While in Canada, municipalities such as Markham have wholly adopted Smart Growth policies while other such as Toronto have begun adopting key components such as complete street designs.[9] [10] As the flaws and frictions of automobile centric urban design are made apparent, city planners and urban designers, especially in North America, are shifting cities away from automobile dependency towards a diverse set of mobility solutions.

The shift in attitude regarding the role of automobiles within the city has again brought into question how best to design the public fabric of the city to accommodate both the mobility and public use. In response to these challenges imposed by automotive infrastructure, urban planners and policy makers have taken differing approaches in redesigning streets.

One approach, popular in both the United States and Canada, is a "Complete Street", characterized by separate lanes with clear delineations for bicycle traffic, public transit in addition to lanes for regular traffic and raised

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8 American Planning Association. "Growing Smart." https://www.planning.org/growingsmart/.

9 Ciy of Markham. "Strong Communities, Strong Economy, Clean, Healthy Environment." https://www.markham.ca/wps/portal/Markham/BusinessDevelopment/MarkhamCentre/TheMarkhamCentreStory/Vision/SmartGrowth.

10 City of Toronto. "Complete Streets." January 24, 2018. https://www.toronto.ca/services-payments/streets-parking-transportation/enhancing-our-streets-and-public-realm/complete-streets/.

sidewalks. The definition and design focus of complete streets is outlined by the City of Toronto as such:

"Complete streets are designed to consider the needs of all users, such as people who walk, bicycle, take transit or drive, and people of varying ages and levels of ability."[11]

By nature of their design, it is clear that the focus is to ensure the safety and comfort of pedestrians and cyclists. In designating wider sidewalks and defined bike lanes, the design of the street promotes pedestrian activity, more active lifestyles and more attractive streets. Although the segregation of space is effective in reducing collisions between automobiles, cyclists and pedestrians, it is rather impractical in its use of space and especially difficult to implement in pre-existing streets. Many pre-existing streets within city cores are not able to widen to accommodate the width of a bike lane on both sides of the street or designated lanes for public transit. Furthermore, the addition of bike lanes or wider sidewalks will inevitably diminish the effectiveness of the cars due to the reduced number of lanes and street parking. As such, complete streets should not serve as a blanket solution for every street within a city, but applied in a strategic network to promote street life in one area of the city and automotive efficiency in others. In implementing Complete Street designs, cities will need to have a comprehensive understanding of the priorities of each of their streets and be strategical in placing them so that safety, comfort and efficiency are maximized throughout the city.

Figure 2.11 -Raised bike lane also serving as a boarding platform on Roncesvalles Avenue

Figure 2.12 - Planters delineating bike lanes on Simcoe Street

11 City of Toronto "Complete Streets." January 24, 2018. https://www.toronto.ca/services-payments/streets-parking-transportation/enhancing-our-streets-and-public-realm/complete-streets/.

Figure 2.13 - Separate bike lanes and streetcar traffic on Queens Quay

Figure 2.14 - Designated street car tracks on St Clair

A more nuanced and flexible approach to managing automotive traffic are “woonerfs” (living streets) which, as opposed to the design of complete streets, aim to alleviate the problems of automotive traffic by sharing space with pedestrian activity. Originating in the Netherlands, woonerfs are characterized by the removal of all curbs, signage and demarcations while extensively using landscaping elements and street furniture to shape the street. Furthermore, the street is designed to be narrow as well as full of twists and turns such that automobiles are forced to have difficulty manoeuvring through the street. As a result, motorists are forced to slow down and pay additional attention when navigating through the street, in theory reducing the amount of collisions.[12] Woonerfs are primarily used in residential neighbourhoods, rather than major thoroughfares, as the design enforces a low speed limit and is meant to allow for play and social activity.

In certain circumstances, cities in the US and Canada have also elected to completely remove the car from the equation by establishing pedestrian malls or pedestrian only zones. The shift towards the pedestrian scale and the benefits of walkable neighbourhoods have been championed by Danish architect and urban designer Jan Gehl, as well as American urban designer Jeff Speck. As a result of Gehl and Speck’s numerous publications and built projects, cities around the world have realized the situational benefits of closing off previously car dominated roads and transforming them into pedestrianized streets.[13] Two prime examples are the Time Square renovation in New York and Strøget in Copenhagen. The Times Square renovation, designed by Snøhetta, completely transformed the landscape by building a

Figure 2.15 - Woonerf in Madison, WI.

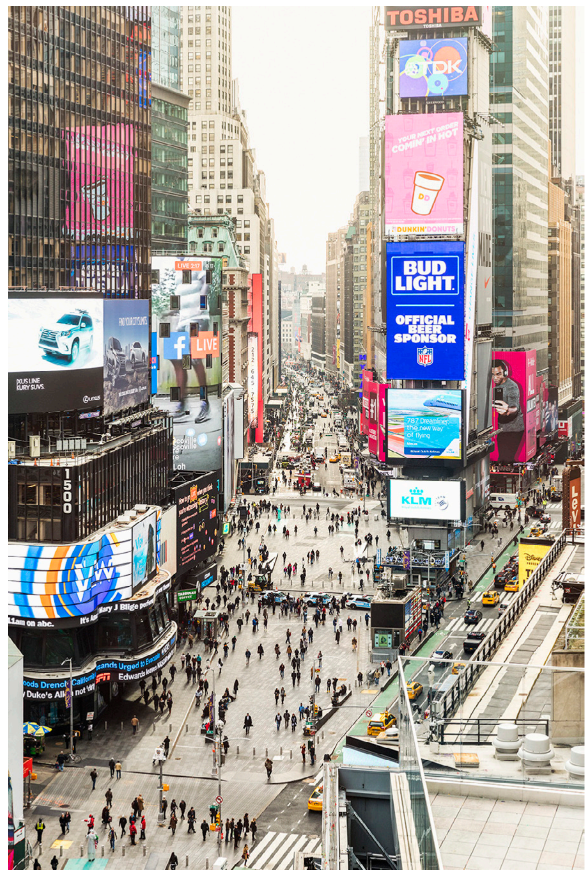


Figure 2.16 - Pedestrianization of Times Square

12 Eran Ben-Joseph. “Changing the residential street scene: Adapting the shared street (woonerf) concept to the suburban environment.” (Journal of the American Planning Association 61, no. 4 1995), 504-515.

13 Thejas Jagannath. “Pedestrianized Streets Create Important Public Spaces.” (Medium. October 16, 2016). https://medium.com/@thejas009/pedestrianized-streets-create-important-public-spaces-fdbea73d8268.

Figure 2.17 - Example of a Woonerf in the West Don Lands

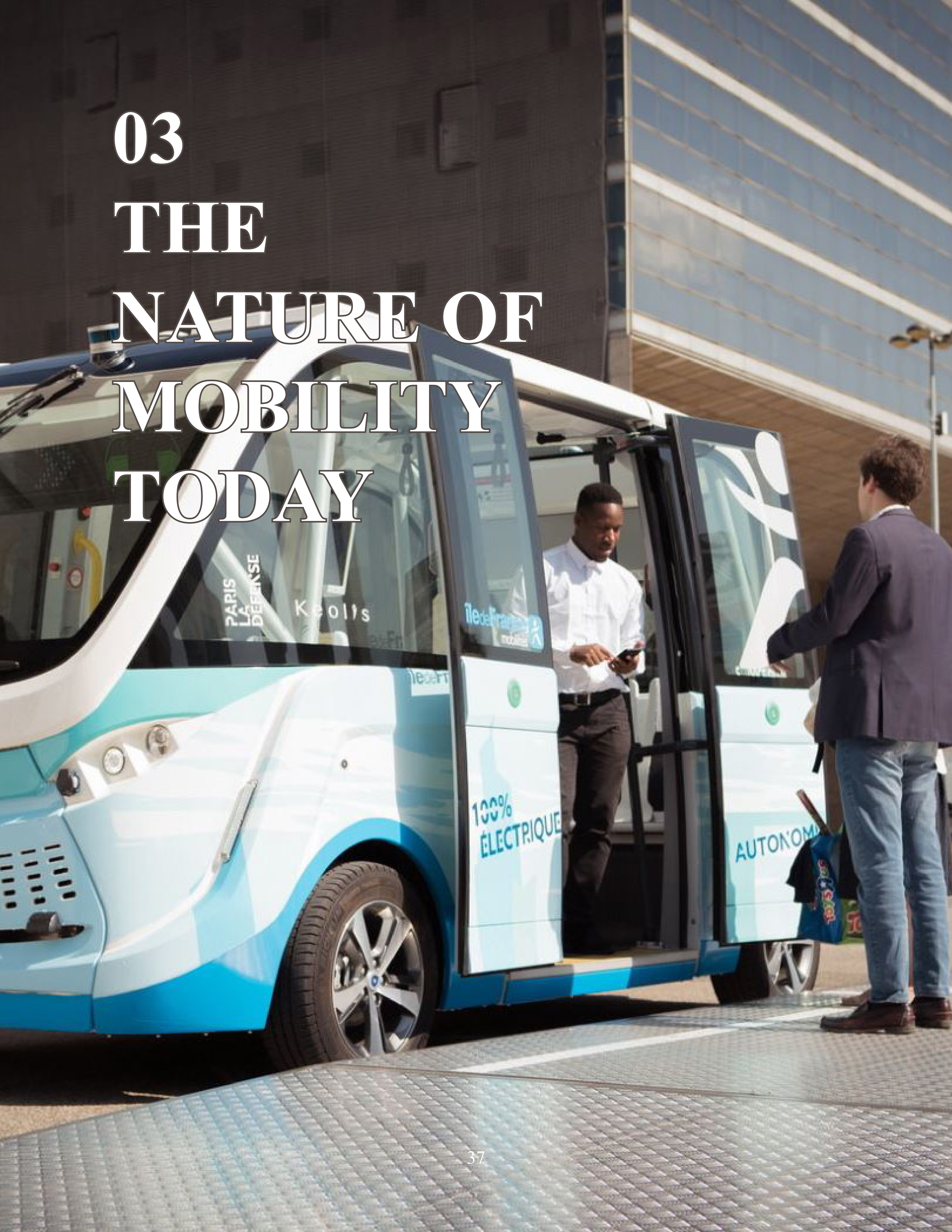
Figure 2.18 - Before and after of Times Square transformation

permanent pedestrian plaza, repaving large portions of the famous square, installing street furniture and restricting vehicle access. The pedestrianization reimagined the area to be a pedestrian oasis and is claimed to have decreased pedestrian injuries by 80%, vehicular accidents by 80% and overall crime by 20%.[14] Copenhagen's pedestrian street, Strøget, is the backbone of the city and is the flagship project of Jan Gehl's pedestrian policies. One of the longest pedestrian streets in Europe, the project is a shining example of a well-implemented pedestrianization that creates plentiful amounts of street life through public plazas, cafés, retail stores, street furniture and historic areas. Although pedestrian malls or pedestrian zones are great opportunities for cities to create a bustling urban neighbourhood, the concept is very restrictive in so far as it can only be implemented in core, high density areas of cities. Pedestrian streets necessitate high amounts of foot traffic and density of commercial stores in order to be successful, requirements often only found in downtown or historic areas of a city.

14 Snøhetta. "Times Square." Accessed August 27, 2018. https://snohetta.com/projects/327-times-square.

Figure 2.19 - Strøget in Copenhagen

03 THE NATURE OF MOBILITY TODAY



3.1
Autonomous Technology Today

Autonomous vehicle technology is still primarily in its developmental stages, but its arrival in the near future is inevitable. Cars today are currently situated on Level 1 or Level 2 of autonomous driving as defined by SAE International, a widely used and recognized classification system which categorizes autonomous vehicle capabilities based on the amount of driver intervention required, ranging from fully manual (Level 0) to fully automated (Level 5).[1] Current standard technologies in cars such as cruise control, parking assistance and lane keeping which all provide assistance to the driver make up the first two levels. Nearly every automaker and several big tech companies around the world are engaged in autonomous vehicle research and development to further increase the amount of automation possible within their vehicles. Most AV development has reached Level 3, which is defined as being "capable of taking full control and operating during select parts of a journey when certain operating conditions are

Figure 3.0 - (previous page) Navya Autonomous Shuttle

1 Kyle Hyatt, and Chris Paukert. "Self-driving Cars: A Level-by-level Explainer of Autonomous Vehicles." (CNET. March 21, 2018.) https://www.cnet.com/roadshow/news/self-driving-car-guide-autonomous-explanation/.
2 Ibid.

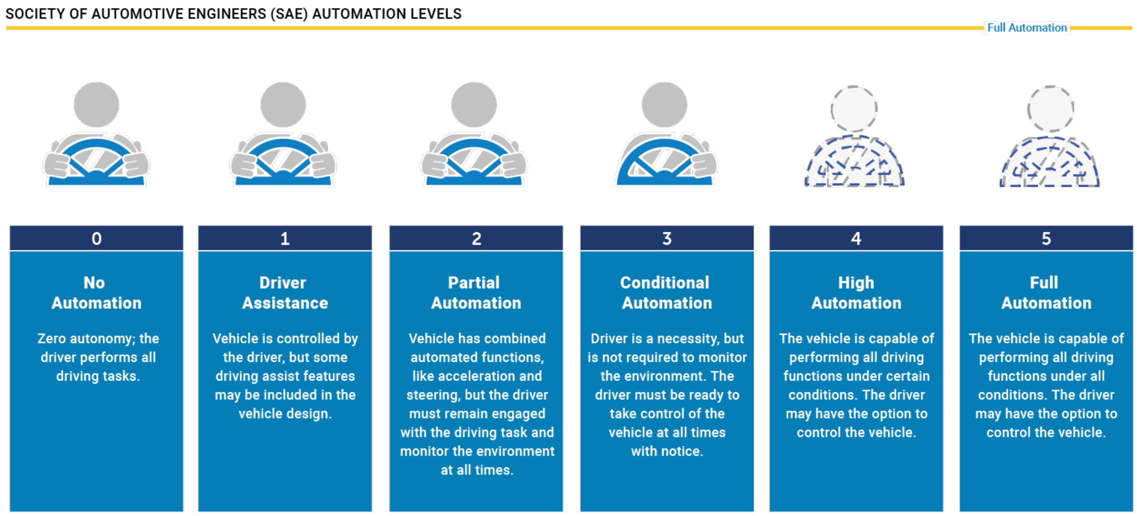


Figure 3.1 - SAE designated levels of vehicle automation

Figure 3.2 - Tesla's autopilot systems are classified as Level 2 and require constant user control at all times

met.”[2] What this translates to in actuality is that AVs are currently able to autonomously navigate traffic conditions within a pre-defined area during most weather conditions. No AVs are above level 3 in automation. As the technology develops and increasing amounts of driving responsibility is offloaded to autonomous systems, how vehicles behave and interact with the built environment will drastically change. This revolution in mobility is closer to reality than many may think. Honda and Toyota predict themselves to have self-driving technology capable of navigating highways by 2020. BMW and Renault-Nissan expect to have fully autonomous cars by 2021 and 2025 respectively.[3] Automakers are not the only industry to explore the revolutionary possibilities brought upon by autonomous technology.

Numerous other industries impacted by autonomous technology are also exploring the wealth of possible opportunities. Uber has already been trialling self-driving cars in the past few years, with the ultimate goal to replace their fleet of human driven vehicles with an autonomous fleet. To this end, Uber has formed numerous partnerships with automakers including a deal with Volvo to purchase up to 24,000 self-driving cars beginning in 2019 as well as receiving a $500 million investment by Toyota to jointly develop self-driving cars.[4] [5] Tech companies, such as Navya and Easymile, are also focusing on public transit through the development of autonomous shuttles to alleviate first and last mile challenges.[6] The US Postal

Figure 3.3 - An Uber self-driving car in Pittsburgh

Figure 3.4 - An Easymile autonomous shuttle

Figure 3.5 - Nuro self-driving delivery vehicle

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3 Jon Walker. “The Self-Driving Car Timeline - Predictions from the Top 11 Global Automakers.” (TechEmergence. July 20, 2018.) https://www.techemergence.com/self-driving-car-timeline-themselves-top-11-automakers/.

4 Leo Kelion. “Uber and Volvo Strike Deal for 24,000 Self-drive Cars.” (BBC News. November 20, 2017.) https://www.bbc.com/news/technology-42055841.

5 “Toyota to Invest $500m in Uber in Driverless Car Deal.” BBC News. August 27, 2018. Accessed August 28, 2018. https://www.bbc.com/news/business-45324753.

6 Sasha Lekach. “Driverless Shuttles Will Beat Other Autonomous Vehicles to the Road.” (Mashable. May 26, 2018.) https://mashable.com/2018/05/26/driverless-self-driving-autonomous-shuttles-vans/#Dmj7Kf6P.sqm.


Figure 3.6 - Starship Technologies delivery robot

Service, in a report by the Office of the Inspector General released in 2017, detailed its plan to include autonomous technology in their 228,000 vehicle fleet in order trim costs and modernize their fleet. The plan aims to pilot 10 prototypes on rural routes in 2019 and lead up to a full scale countrywide rural deployment between 2022 and 2025.[7] The advent of autonomous technology has the potential to completely revolutionize numerous industries and their interactions with the built environment.

7 Aarian Marshall. "The US Postal Service Is Working on Self-Driving Mail Trucks." (Wired, Conde Nast, 9 Oct. 2017), www.wired.com/story/postal-service-office-self-driving-mail-trucks/.

3.2
Precedents and Deployments

Although self-driving technology is still mostly in development and undergoing pilot phases throughout the industry, autonomous vehicles have already been deployed in a handful of locations around the world in a limited fashion. In most cases, AV deployments are being used for public transportation rather than private use and restricted to a pre-defined route. In 2016, the city of Helsinki introduced a regular, scheduled bus line to the Helsinki zoo operated by self-driving shuttles. After a one-year successful pilot phase, the city then further decided to permanently implement the bus line and is continuing to explore future possibilities for the technology.[8] Sion, Switzerland has also been utilizing autonomous shuttles as a mobility solution. Since their deployment within the city in December 2015, over 60,000 passengers have taken the free shuttle which transports people from the city's Old Town to the central train station for free. The city has also announced the expansion of the

Figure 3.7 - Nuro self-driving delivery vehicle

Figure 3.8 - Nuro self-driving delivery vehicle

8 City of Helsinki. "Helsinki to Launch Self-Driving Bus in Regular Service." (Helsingin Kaupunki. June 15, 2017.) https://www.hel.fi/uutiset/en/helsinki/helsinki-self-driving-bus-regular-service.

service in 2018, aiming to double the length of the original 1.5 mile route and include areas with heavier traffic.[9] Autonomous shuttles have also been deployed in other cities around the world such as Paris, Lyon, Tokyo, Perth, Michigan and Hong Kong in similar capacities.[10]

Current deployments of autonomous vehicles are also seen within the taxi industry. Uber has deployed self-driving cars in numerous American cities including San Francisco, Tempe and Pittsburgh, travelling over one million autonomous miles over 30,000 passenger rides.[11] A private taxi fleet is also being deployed by Voyage to retirement villages in the US. After a successful launch in a retirement suburb in San Jose, "The Villages", a retirement suburb in Florida, is introducing a fleet of self-driving taxis to help its 125,000 senior residents travel within the community. The door-to-door service, accessed through an app, will allow residents to travel anywhere within the bounds of the community, which contain 750 miles of road, 3 distinct downtown areas and a whole host of other retail areas.[12] These small-scale deployments begin to paint a picture of how autonomous vehicles have the potential to be implemented in the future.

Figure 3.9 - The Villages retirement community in Florida

Figure 3.10 - Voyages self-driving Taxi

9 Swiss Info. "Sion driverless bus service to be expanded." October 17, 2017. Accessed March 30, 2018. https://www.swissinfo.ch/eng/on-board_sion-driverless-bus-service-to-be-expanded/43604204

10 Navya. "AUTONOM SHUTTLE." https://navya.tech/en/autonom-en/autonom-shuttle/.

11 Joe F. Rodriguez "Uber Buys 24,000 New Self-driving Cars, but Not for SF." (The San Francisco Examiner. November 20, 2017) http://www.sfexaminer.com/uber-buys-24000-new-self-driving-cars-not-sf/.

12 Daniel Thomas. "US Retirement Village to Have 'largest' Self-driving Taxi Scheme." (BBC News. January 11, 2018) http://www.bbc.com/news/technology-42648301.

In addition to these deployments, architecture firms and other private organizations have attempted to envision how autonomous vehicles might fit into the cities of the future. In a submission to the Audi Urban Future Award, BIG's "(Driver)less is more" proposal imagines a thin layer of reprogrammable sensors embedded within the road, able to visualize travel flows of autonomous vehicles to the public. As a result of the technology, BIG envisions a city in which the street can seamlessly accommodate both pedestrians and vehicular traffic.[13] Kinder Baumgardner, managing principal of landscape and urban design firm SWA, has also recently published a paper proposing several potential impacts on automotive infrastructure as a result of the proliferation of autonomous vehicles. Entitled, Beyond Google's Cute Car, Baumgardner envisions what the highways, parking lots, parking garages and cul-de-sacs of today could possibly evolve into.[14]

Figure 3.11 - "Driver(less) is more" by BIG for the Audi Urban Future Award

13 Sebastian Jordana. "BIG's Proposal for the Audi Urban Future Award." (ArchDaily. September 10, 2010.) https://www.archdaily.com/77103/bigs-proposal-for-the-au-di-urban-future-award.

14 Patrick Sisson. "Driverless Cars Will Shrink Our Roads and Radically Reshape Urban Space." (Curbed. May 26, 2016) https://www.curbed.com/2016/5/26/11787632/driverless-cars-will-shrink-our-roads-and-radically-reshape-urban.

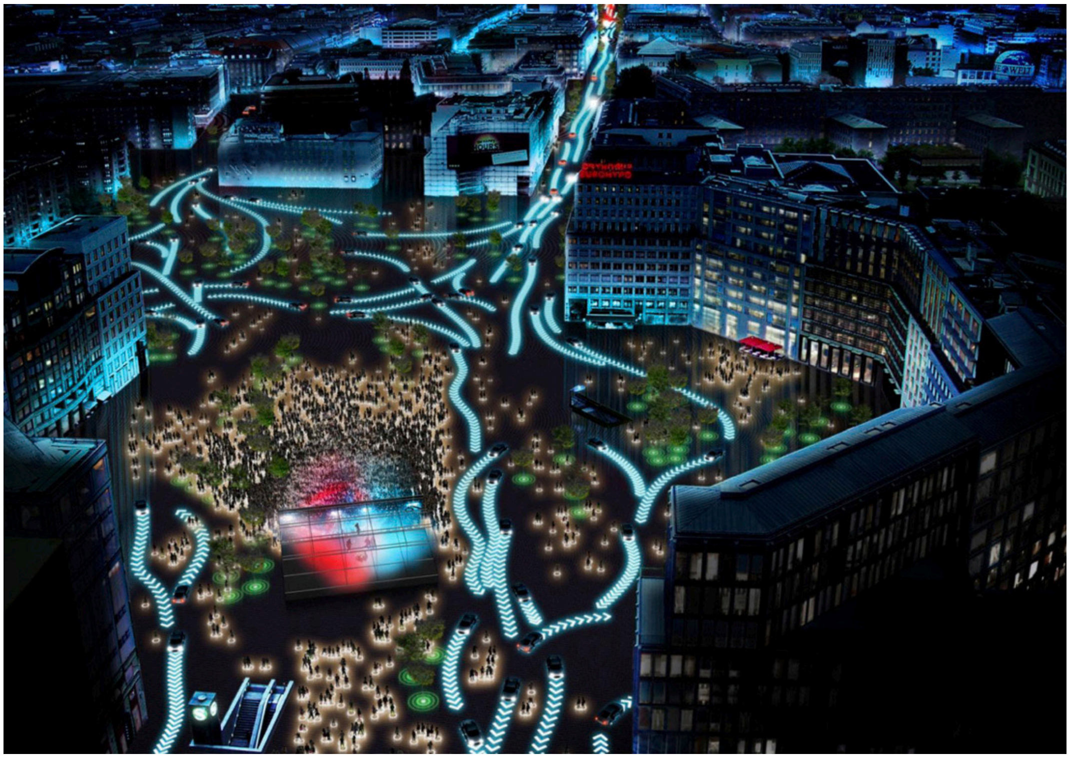

Figure 3.12 - “Driver(less) is more” by BIG for the Audi Urban Future Award

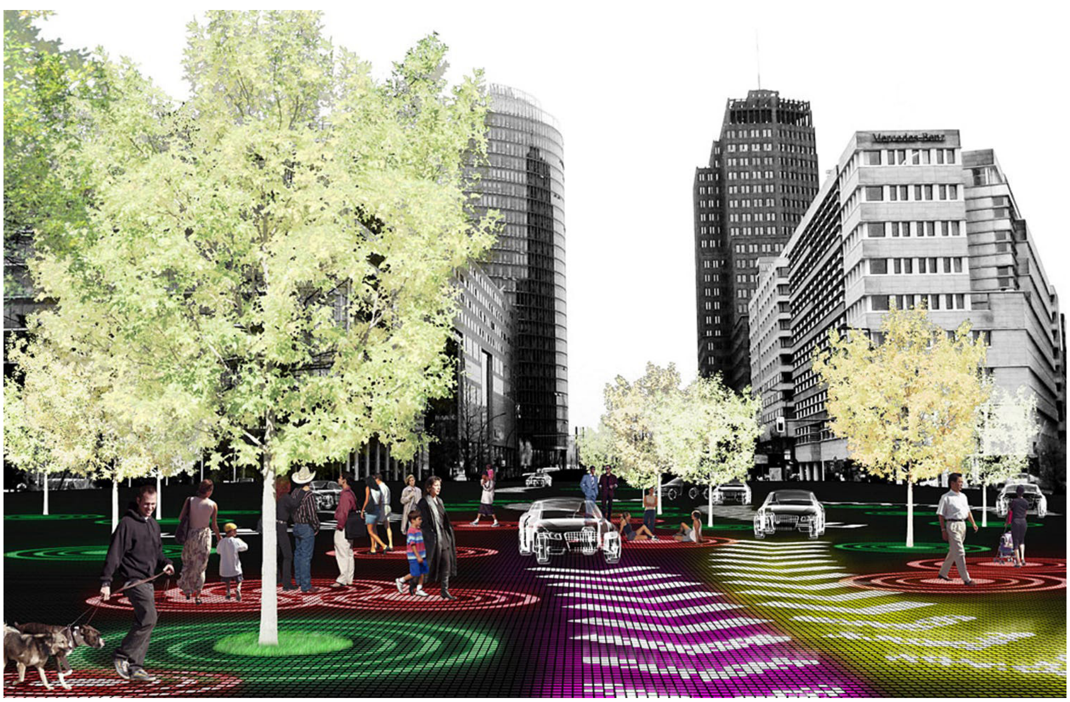

Figure 3.13 - “Driver(less) is more” by BIG for the Audi Urban Future Award

Figure 3.14 - Transforming the cul-de-sac in Kinder Baumgardner's "Beyond Google's Cute Car"

Figure 3.15 - Transforming the highway in Kinder Baumgardner's "Beyond Google's Cute Car"

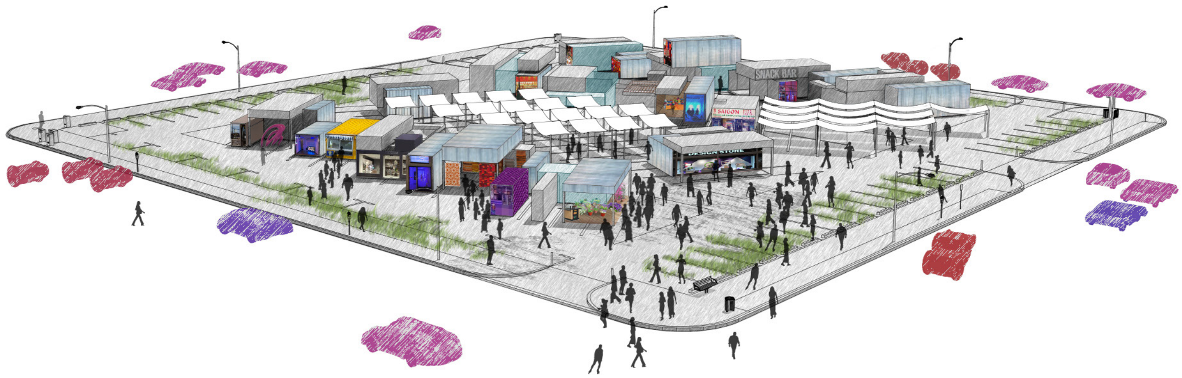

Figure 3.16 - Transforming the parking lot in Kinder Baumgardner's "Beyond Google's Cute Car"

Figure 3.17 - Transforming the parking garage in Kinder Baumgardner's "Beyond Google's Cute Car"

04
TORONTO

4.1
A City Addicted to Cars

The largest and most populous city in Canada, the city of Toronto and its suburbs rely heavily on the use of automobiles to function. A 2016 University of Toronto survey showed that 57% of all the city's residents utilized a car as their primary mode of travel, with this percentage going up to 75% in Toronto's outer wards. The survey also showed that nearly half of households in Toronto had 1 available vehicle while a quarter had 2 or more vehicles.[1] Although the widespread use of cars has allowed city residents to move quickly and conveniently throughout the city as well as live comfortable in suburbs, it has also caused numerous headaches. The city's road network is at its limit and the space reserved for vehicles within the city have ballooned out of control. Collisions between drivers and cyclists or pedestrians have become a daily occurrence.[2] The municipal government has been forced to invest

Figure 4.0 - (previous page) Sidewalk Labs rendering of proposed new Toronto neighbourhood

Figure 4.1 - A Canada Post van parks itself on the sidewalk, blocking both pedestrians and cyclists

1 *Transportation Tomorrow Survey Summary by Ward*. Publication. (Department of Civil Engineering, University of Toronto. 2016) http://dmg.utoronto.ca/transportation-tomorrow-survey/tts-reports.

2 Ben Spurr. "More than 1,000 Cyclists and Pedestrians Hit on Toronto Streets since June 1." (Thestar.com. September 23, 2016.) https://www.thestar.com/news/gta/transportation/2016/09/23/more-than-1000-cyclists-and-pedestrians-hit-on-toronto-streets-since-june-1.html.

Figure 4.2 - A graffiti covered laneway in Toronto

millions of dollars into increasing pedestrian safety from vehicles.[3] Gridlock and congested highways are costing Toronto an estimated $6 billion per year due to lost time. Meanwhile, garages, driveways, street parking and laneways crowd out much needed urban space that could otherwise become additional housing or space for social play. The relationship between Toronto and cars has become abusive, a necessary evil. The current situation is unsustainable, especially as Toronto continues to grow in population and place additional strain on the already overloaded infrastructure. A solution must be found, one that retains the capability and flexibility of current vehicles but also reduces the friction amongst the many users within the city.

Figure 4.3 - Local residents stop at a McDonalds to pick up coffee and groceries

Toronto is a city addicted to cars. Its use and pervasiveness have permeated into the very core of its identity. Getting a driver's license has become a ritual or baptism of sorts for Torontonians. Teenagers race to get their license right as they turn 16 and new immigrants to the city put it on their priority list of things to do when settling in Toronto. Obtaining a driver's license and the ability to drive seems almost a necessity to living life in Toronto. 62% of the population of Toronto own driver's licenses and a majority claim the car as their primary mode of travel.[5] As the city developed further around the range of mobility offered by cars, its dependence on them became increasingly acute. It is now practically impossible to live a pedestrian life in the city's many suburbs. Buildings are spaced so far apart that cars are the only feasible way to get anywhere. Simple daily tasks such as grabbing your weekly groceries or a bite to eat with friends in the suburbs necessitates the turning of the key and revving of the engine. The anatomy

3 CBC News. "Vision Zero Plan Gets $13M Boost in Wake of 'troubling' Deaths - but Some Say Action Needed Now" June 15, 2018. https://www.cbc.ca/news/canada/toronto/vision-zero-plan-1.4708257.

4 Madhavi Acharya-Tom Yew. "Gridlock: The $6 Billion (at Least) Problem." (Thestar.com. November 29, 2013.) https://www.thestar.com/business/2013/11/29/gridlock_the_6_billion_at_least_problem.html.

5 *Transportation Tomorrow Survey.* 15.

of the city is also reflective of this addiction. A house without a garage or space to park your car is unheard of. Building lots for city shops, churches and community centres allocate more space to parking than the buildings themselves. The minimum parking requirements written into the city building codes are proof enough of the car's dominance as the primary way of travel. Working as an architect, I often found myself having to scale the buildings I was working on according to the amount of parking spots I could fit in.

The dependence on the car is admittedly less prevalent the closer you get to the city centre, but the tensions and frictions it causes become even harsher. Although the proximity of buildings means that residents of the city can access more through walking or cycling, it also means that cars have less space to operate. What would have been a 6-lane arterial in the suburb becomes a 2-lane street with street parking in the inner parts of the city. What is a 10m wide street in a suburban residential street flanked with driveways becomes a one-way 6m street that has to accommodate more traffic, more pedestrians and more parking. As a result, the realm of the car pushes to its utmost boundaries and begins to invade areas designated for pedestrians and cyclists. This strenuous sharing of space has lead to critical amounts of collisions within the city, sometimes fatal. According to police statistics, there was a total of 1,958 pedestrian collisions and 1,070 cyclist collisions reported for the year 2016, just over 8 collisions per day.[6] It is also not an uncommon sight in the city to see delivery vans parked over sidewalks or cars parked in bike lanes. Placing parking for cars in denser Toronto neighbourhoods turns into a puzzle, in which every available nook and cranny becomes designated as parking. Narrow residential streets are lined with street parking, destroying any

Figure 4.4 - A delivery truck parks itself over the pedestrian sidewalk in Little Portugal

Figure 4.5 - Parking placed wherever possible, invading on pedestrian space

6 Ben Spurr. *"New Numbers Reveal 2016 Was Toronto's Deadliest Year for Pedestrians in at Least a Decade."* (Thestar.com. January 06, 2017.) https://www.thestar.com/news/pedestrian-road-safety/2017/01/06/new-numbers-reveal-2016-was-torontos-deadliest-year-for-pedestrians-in-at-least-a-decade.html.

Figure 4.6 - A car and FedEx delivery truck park themselves in the middle of the road, reducing traffic flow on Bay street by half and blocking the bicycle lane

Figure 4.7 - Residents find every possibly nook and cranny to park their vehicles

possibility for social space. The sidewalks of commercial streets, that are often at the heart of Toronto's neighbourhoods, become pinched with barely enough space for 3 people to walk side by side. Parking in denser areas become such an issue that parking spots are valued from $45,000 in less central areas to upwards of $80,000 in parts of central Toronto.[7] The car has been built into the DNA of Toronto and has become inextricable from the city.

Yet, in spite of Toronto's addiction and dependence on the car, the city and its people have been fighting back to regain control of the city. The municipal government of Toronto has begun implementing a 5-year plan dubbed the Vision Zero Plan, investing $100 million into a wide variety of road safety measures in the hopes of reducing traffic accidents.[8] The plan addresses a variety of users including pedestrians, cyclist, aggressive drivers, seniors and school children and includes solutions such as expansions of bike lanes, speed reductions, redesigning of roads, construction of speed bumps and increased pavement markings.[9] The city has also implemented other initiatives to shift the balance away from cars as the primary method of mobility for Torontonians. The King Street Transit Pilot project in the downtown Toronto core is one such initiative, targeting the city's busiest surface transit route. The project "aims to improve transit reliability, speed, and capacity" by banning private vehicle traffic along the street as well as through the streets intersections in order to give

Figure 4.8 - Local businesses take over the street and cordon off an area for bicycle parking

7 Josh Sherman. "Here's How Parking Costs Can Vary at New Toronto Condo Developments." (Livabl. June 28, 2017.) https://www.livabl.com/2017/06/heres-parking-costs-can-vary-new-toronto-condo.html.

8 CBC News. "Vision Zero Plan Gets $13M Boost in Wake of 'troubling' Deaths - but Some Say Action Needed Now" June 15, 2018. https://www.cbc.ca/news/canada/toronto/vision-zero-plan-1.4708257.

9 City of Toronto. "Vision Zero Emphasis Areas." July 18, 2018. https://www.toronto.ca/services-payments/streets-parking-transportation/road-safety/vision-zero/emphasis-areas/.

10 City of Toronto. "King Street Transit Pilot Overview." January 31, 2018. https://www.toronto.ca/city-government/planning-development/planning-studies-initiatives/king-street-pilot/king-street-transit-pilot-overview/.

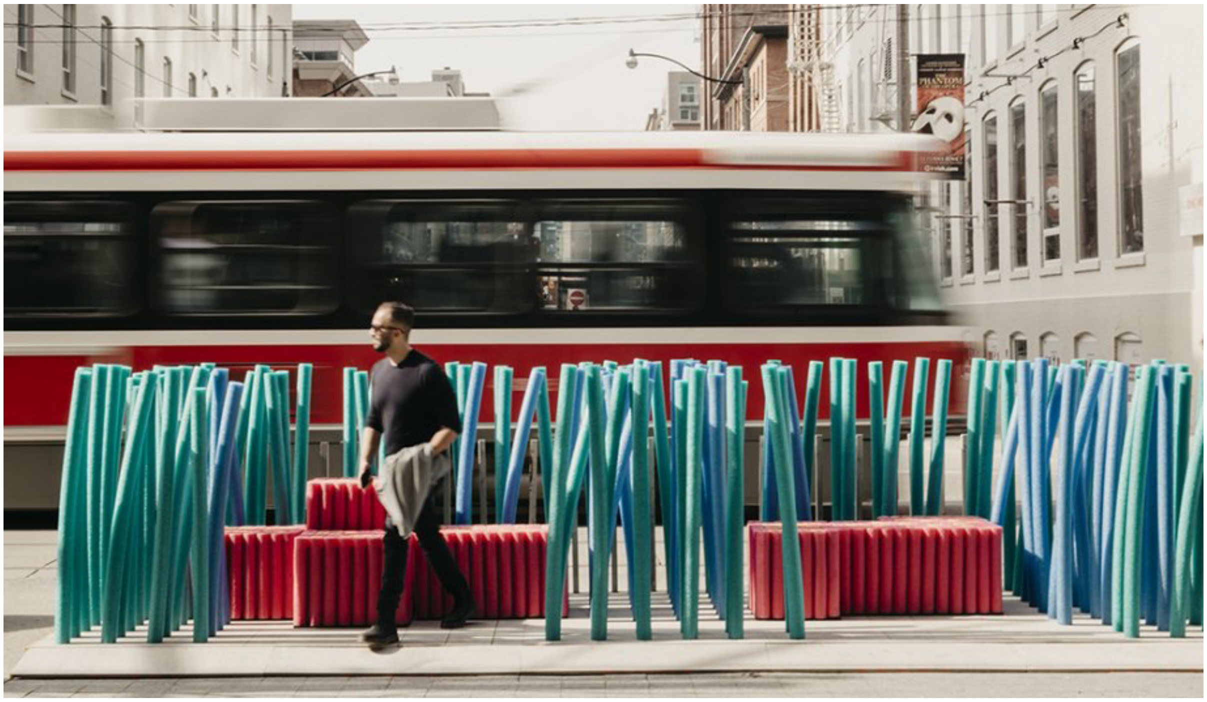

Figure 4.9 - Temporary installation by VPA Studio for the Everyone is King project which is part of the King Street pilot

Figure 4.10 - Benches and seating by Plant Architect for the Everyone is King project which is part of the King Street pilot

streetcars priority.[10] Cycling within the city is also receiving funding from both the municipal and provincial governments. The Ontario government, through the Ontario Municipal Commuter Cycling Program, is investing $93 million into cycling infrastructure of which $25.6 million is allocated to Toronto. The funds are planned to help deliver Toronto's Ten Year Cycle Network Plan and more than double the size of Toronto's Bike Share program.[11] As further evidence that the city of Toronto is shifting towards more cyclist friendly streets, it approved by a vote of 36-6 its Bloor Street Bike Lane Pilot Project, making permanent bike lanes along the major street at the cost of increased travel times for motorists.[12] The fight for the pedestrian is also taking place within the city. Numerous areas in the centre of Toronto have put forth proposals to redesign their streets to better accommodate pedestrian traffic. One such example is the John Street Corridor Improvements project by the City of Toronto, aiming to "transform John street into a 'cultural corridor' by redesigning the streetscape". The proposal shifts the current balance of space towards pedestrians by widening the sidewalk and reducing the width of the roadway to one lane of traffic in each direction. It also plans to redesign the street with additional trees, lighting, public art, new paving and curbs in order to promote space that can be used for special events and festivals.[13] Another proposal by the city takes aim at its most famous street, Yonge street. The Downtown Yonge Business Improvement Area published a report in 2015 detailing the

Figure 4.11 - Cyclist utilizing the bike lane along Bloor Street

11 Government of Ontario. Ministry of Transportation. "Major New Investment to Make Cycling Safer and More Convenient." News release, December 4, 2017. News.ontario.ca. https://news.ontario.ca/mto/en/2017/12/major-new-investment-to-make-cycling-safer-and-more-convenient.html.

12 Ben Spurr. "Toronto Council Votes to Make the Bloor St. Bike Lanes Permanent." (Thestar.com. November 07, 2017.) https://www.thestar.com/news/gta/2017/11/07/toronto-council-votes-to-make-the-bloor-st-bike-lanes-permanent.html.

13 City of Toronto. "John Street Corridor Improvements." June 04, 2018. https://www.toronto.ca/community-people/get-involved/public-consultations/infrastructure-projects/john-street-corridor-improvements/.

results of their public consultation for its planned revitalization. It noted that the sentiment was largely for a more pedestrian friendly street by way of designing for the human scale. Moreover, the most desired change from the public was for the street to be closed to vehicular traffic on weekend. The findings were in line with the proposed narrowing of the street from four lanes to two and accommodation for street life such as patios and other street furniture.[14] The city of Toronto is currently in a state of transition and rebalancing. For all its dependence on the car to function, the city and its residents have also recognized that the car's continued dominance is unsustainable. The city is grappling with the fact that it needs to balance the necessity of the car and its oppressive nature on pedestrians, cyclists and everyday life in Toronto. Consequently, it is with great optimism that the city of Toronto views the advent of autonomous vehicles, which promises to alleviate the overbearing spatial requirements of cars while maintaining its convenience and efficiencies.

14 *Stefan Novakovic. "Yonge Love: Glimpsing Yonge Street's Pedestrian-Friendly Future." (Urban Toronto. November 20, 2015.) http://urbantoronto.ca/news/2015/11/yonge-love-glimpsing-yonge-streets-pedestrian-friendly-future.*

Figure 4.12 - Rendering of the proposed John Street Cultural Corridor

4.2
Autonomous Vehicles in Toronto

Toronto finds itself in the goldilocks zone for autonomous vehicle development and deployment. The city fulfills 3 major criteria for the development of the revolutionary technology: support from the government, investments from private companies and an automobile dependent city in distress. In terms of government support, all 3 levels of government, federal, provincial and municipal, have already begun investigating and investing into the development of the technology. Tech companies such as Uber, as well as auto companies such as GM, have established autonomous vehicle development in Toronto in the past year. Finally, as covered in the previous chapter, Toronto is a city already all too familiar with the car and is under pressure to find a better solution to its mobility needs. The situation Toronto finds itself in has lead to the city becoming a pioneer for autonomous technology and positions itself to be on the forefront of the next revolution in mobility.

Figure 4.13 - Prime Minister Justin Trudeau and Premier Kathleen Wynne at GM's announcement for new autonomous vehicle HQ in Markham

The support and interest from all 3 levels of government for the development of autonomous vehicles has propelled Toronto to the forefront of the next revolution in mobility. On the federal level, the Canadian Senate has

Figure 4.14 - Transportation Minister Marc Garneau tests an autonomous shuttle

been consulting with researchers and experts since 2016, culminating in the release of a report 2 years later, on January 2018. The report provides 16 key recommendations for the federal government to undertake in order to pivot and adapt the country to the inevitable advent of autonomous vehicles.[15] On inevitability, the report writes, "It is not a matter of if but of when more sophisticated automated and connected vehicles will arrive on Canadian roads."[16] In addition to recommendations for the creation of safety guidelines and frameworks of use, the report's second recommendation advocates for the implementation of autonomous vehicles policies by all levels of government, a key requirement for the technology to flourish.

"Recommendation 2: Transport Canada engage with provincial and territorial governments, through the Canadian Council of Motor Transport Administrators, to develop a model provincial policy for the use of automated and connected vehicles on public roads. The department should also involve municipalities in this engagement process."[17]

The eagerness of the federal government to promote and innovate, with regards to autonomous technology, is critical in giving cities such as Toronto the inside track in being at the forefront of technological development and implementation.

The provincial government of Ontario is also extremely supportive of autonomous vehicle development and is the leading province in Canada for the technology. The province was quick to the

15 Canada. Parliament. Senate. "Driving Change: Technology and the Future of the Automated Vehicle." https://sencanada.ca/en/info-page/parl-42-1/trcm-driving-change/#collapse-item2.

16 Canada. Parliament. Senate. Standing Senate Committee on Transport and Communication. *Driving Change: Technology and the Future of the Automated Vehicle*. Report. January 2018. https://sencanada.ca/content/sen/committee/421/TRCM/Reports/COM_RPT_TRCM_AutomatedVehicles_e.pdf. 12.

17 Ibid. 13.

plate, launching a 10-year autonomous vehicle pilot program on January 1, 2016, becoming the very first province to allow on-road testing of the technology.[18] The pilot program has since been a major success with multiple participants utilizing the program including academic institutions such as the University of Waterloo and private companies such as Uber and Blackberry. The program was further expanded 2 years later to allow further testing of autonomous technology by lifting the restriction on Level 3 automation and allow testing of platooning.[19] As further evidence of the province's commitment towards the technology, Transportation Minister Steven Del Duca announced during the expansion "Ontario is well-positioned to be a global leader in the development, testing and deployment of connected and automated vehicles and is taking steps to secure that role." Monetary investments have also been made through $80 million in funding to establish the Autonomous Vehicle Innovation Network (AVIN) which aims to support research, development and testing of autonomous technology in Ontario.[20] These steps taken by the provincial government have attracted and encouraged both local and foreign talent to establish a very active autonomous technology development environment around Toronto, further accelerating development of the technology in the city.

The City of Toronto also boasts multiple initiatives, by both public and private entities, working towards the development of autonomous vehicle technology and testing. The municipal government's largest step towards

Figure 4.15 - Senator Dennis Dawson sits in University of Waterloo's autonomous vehicle

18 Canada. Ontario. Ministry of Transportation. "Automated Vehicles – Driving Innovation in Ontario." October 25, 2013. http://www.mto.gov.on.ca/english/vehicles/automated-vehicles.shtml.

19 Allison Jones. "Look Both Ways: Ontario Seeks to Allow Testing of Driverless Cars." (The Globe and Mail. January 09, 2018.) https://www.theglobeandmail.com/news/national/ontario-seeks-rule-change-to-allow-testing-of-driverless-cars/article37539871/.

20 "Ontario Creating Opportunity with Cars of the Future." (News.ontario.ca. November 8, 2017.) https://news.ontario.ca/opo/en/2017/11/ontario-creating-opportunity-with-cars-of-the-future.html.

the new technology has been the creation of a comprehensive report which aimed to form the basis and foundation with which to approach the implementation of autonomous vehicles.[21] Of note, the report consulted the expertise of local academia to strengthen its depth. Academics at Ryerson's School of Urban and Regional Planning conducted several surveys for the report, gauging public acceptance of autonomous vehicles while David Ticoll, a research fellow at the University of Toronto's Innovation Policy Lab, wrote a report entitled "Driving Changes: Automated Vehicles in Toronto" as a way of advising City of Toronto decision makers on short and medium term policy, planning, and investment options that pertain to the advent of self-driving cars.[22 23] The report has since been used to further establish a working foundation for autonomous vehicle development in the city, including informing the city's 3-year Automated Vehicles Work Plan and the TTC's planned deployment of an autonomous shuttle in 2020.[24 25] Multiple private companies have also invested in autonomous vehicle development within the GTA. GM Canada opened a new technology centre at the beginning of 2018 to take advantage of the local tech pool, while Uber similarly opened a research hub around the expertise of University of Toronto professor Raquel Urtasun in the same year.[26 27] Perhaps the largest indication that Toronto

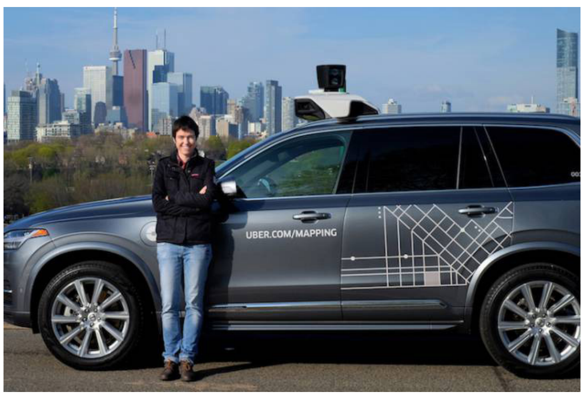

Figure 4.16 - Raquel Urtasun posing next to an Uber self-driving car

21 Barbara Gray. *Preparing the City of Toronto for Automated Vehicles.* Report. (Transportation Services. January 5, 2018.) https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-110665.pdf.

22 Kailey Laidlaw, Matthias Sweet, and Tyler Olsen. *Forecasting the Outlook for Automated Vehicles in the Greater Toronto and Hamilton Area Using a 2016 Consumer Survey*. Report. School of Urban and Regional Planning, Ryerson University.

23 David Ticoll. *Driving changes: Automated vehicles in Toronto*. (Munk School of Global Affairs, University of Toronto, 2015.)

24 City of Toronto. "Preparing for Autonomous Vehicles." Accessed March 26, 2018. https://www.toronto.ca/wp-content/uploads/2018/01/8f04-AVs-TS-Workplan.pdf.

25 Ben Spurr. "Toronto Plans to Test Driverless Vehicles for Trips to and from Transit Stations." (Thestar.com. July 03, 2018). https://www.thestar.com/news/gta/2018/07/03/toronto-plans-to-test-driverless-vehicles-for-trips-to-and-from-transit-stations.html.

might be at the forefront of the next revolution in mobility though, is the focus on autonomous vehicles in Sidewalk Toronto's proposal for a new technology enabled neighbourhood on Toronto's Waterfront. Although steeped in public controversy and questions of implementation, the proposal of a technological utopia backed by the power of the Google and the Canadian government has created large amounts of momentum for the project. These combination of forays into autonomous vehicle technology by both public and private bodies in Toronto have positioned the city to be a leader in a technology that has the potential to completely transform the urban fabric as we know it.

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26 David Paddon. "Ontario Technology Hubs Key for GM Canada's Plans for Driverless Cars: CEO." (The Globe and Mail. January 19, 2018) https://www.theglobeandmail.com/report-on-business/gm-canada-president-says-nafta-needs-to-reflect-changing-technology/article37668363/.

27 Kate Allen. "Uber Opening Toronto Research Hub for Driverless Car Technology." (Thestar.com. May 08, 2017.) https://www.thestar.com/news/canada/2017/05/08/uber-opening-toronto-research-hub-for-driverless-car-technology.html.

28 Salmaan Farooqui. "Sidewalk Labs Reveals Latest Plans for Toronto 'smart City' Development." (The Globe and Mail. August 15, 2018) https://www.theglobeandmail.com/business/article-sidewalk-labs-reveals-latest-plans-for-toronto-smart-city/.

Figure 4.17 - Rendering of new Quayside Neighbourhood by Sidewalk Labs

05a MOBILITY AS A SERVICE

05a
Mobility as a Service

As autonomous vehicle technology develops further and becomes increasingly ubiquitous, the business model of automobiles will undergo a huge shift. The current business model of car ownership is pervasive throughout North America, providing the utmost in convenience, being able to go anywhere at any time right from your doorstep, as well as having the comfort of a private vehicle. Yet over the past decade, we've seen the rise in car sharing options, such as Zipcar and Car2Go, in addition to ride-hailing services, such as Uber and Lyft, rise in popularity. These alternative mobility options threaten to overturn the traditional car ownership model, as millennials are placing less importance on owning a car and are unwilling to pay for their own vehicle. Individual car ownership brings numerous restrictions and challenges to both the individual and city, requiring space to park the vehicle at the origin and destination, paying thousands for an asset that depreciates every year, requires extensive maintenance and ultimately overpowering other users of the city.

Autonomous vehicles are poised to challenge the model of personally-owned vehicles and transition it into a subscription service. Dubbed as Mobility as a Service (MaaS), the future of urban mobility has the opportunity to be cheaper, more flexible and more convenient that mobility today. A shared autonomous vehicle among multiple users has the ability to actively transport people to their destinations throughout the day as opposed to the 96% downtime of current personally owned vehicles. A mobility service also provides increased flexibility in terms of vehicle type, being able to have a truck when buying furniture, a van for soccer practice or a simple 2 seat shuttle for going to a friend's house. It is also economically more feasible, eliminating the enormous initial investment required for a personally owned vehicles as well as upkeep costs such as insurance and maintenance. The question for the urban designers of tomorrow become, how does the city adapt to a shift towards Mobility as a Service? How will the new automotive infrastructure of autonomous vehicles manifest itself? What were the spatial impacts of personally owned vehicles and how can that space be leveraged in the city of the future?

Figure 5.0 - (previous page) Navya and EasyMile autonomous shuttles

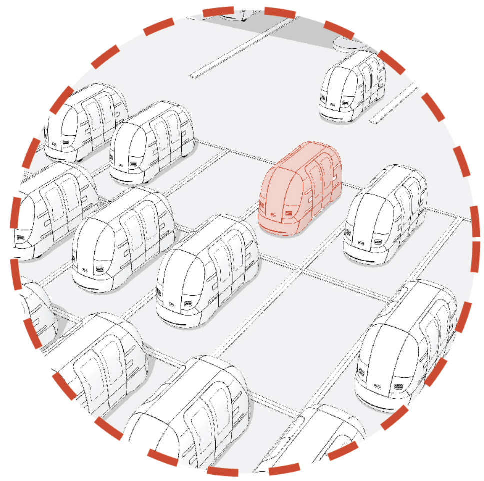
1 Paul Gao, Russell Hensley, and Andreas Zielke. "A Road Map to the Future for the Auto Industry." (McKinsey & Company. October 2014) https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/a-road-map-to-the-future-for-the-auto-industry.

Figure 5.1 - Uber self-drivivng car in Pittsburgh

Figure 5.2 - Navya autonomous shuttle ferrying people in Sion, Switzerland

Summoning an AV

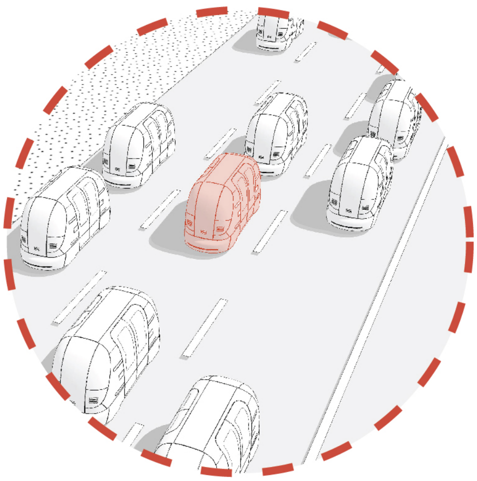
Wanda and John have discovered a new restaurant nearby and decide to go there for dinner. Wanda uses her monthly subscription to Uber to summon an AV from a nearby garage to come pick them up.

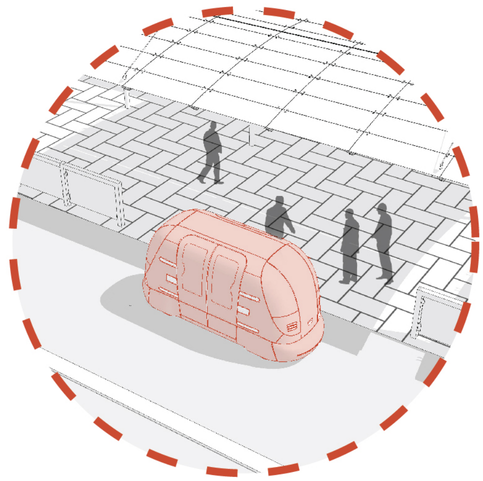


An AV is Found

An available short distance shuttle is located in a nearby storage facility and makes its way to Wanda and John. The estimated arrival time, location and route of the vehicle are transmitted to the customers.

Figure 5.3 - Illustration of how Mobility as a Service would work with autonomous vehicles



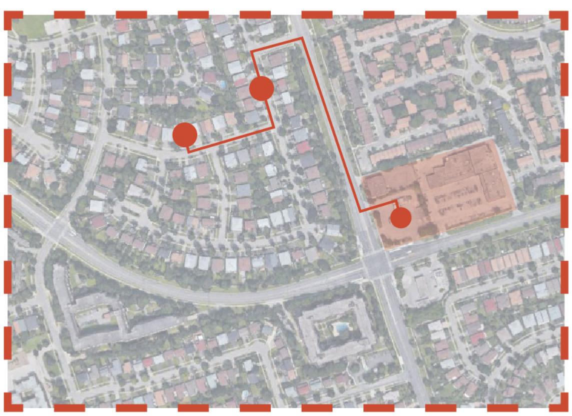


Getting There

After picking Wanda and John up, the vehicle takes a slight detour picking up another couple of passengers going to the same destination. The AV then calculates the optimal route to the destination and travels to the programmed location.

Drop-Off

The AV stops at one of a series of drop-off points at the destination and unloads its passengers. Depending on the situation, the vehicle can then proceed to pick up another passenger or recharge its batteries at a nearby garage.



L'Amoreaux

In exploring the possibilities of MaaS, the suburbs of Toronto provide a good starting point in understanding how the shift from car ownership to a subscription model could pan out in the city of the future. The neighbourhood of L'Amoreaux, a typical suburb in Scarborough located in the northeast of Toronto, could stand to drastically change as Mobility as a Service becomes the norm. Situated close to both Highway 404 and Highway 401, the majority of resident's preferred method of travel is by car. The average number of available vehicles per household is 1.5, with around one third of households owning 2 cars. It is not an exaggeration to say that almost every person in L'Amoreaux takes an automobile to get anywhere, whether that be driving themselves, as a passenger in a personal vehicle or by way of public buses.

Retail plazas located in between residential neighbourhoods, frequently consisting of local restaurants, grocery stores and local businesses, are daily stops for local residents on their way to and from home. These plazas are poised to radically transform as MaaS becomes ubiquitous. They have the potential to become central community hubs for nearby residential neighbourhoods, providing a place to play, socialize, gather and take care of daily needs. Without the need for destination parking for personal cars, the vast amounts of space typically reserved for parking lots can be transformed into additional retail space or even a public plaza for the neighbourhood. The shift towards MaaS will densify nodes of activity, intensifying these plazas with a wide variety of public services such as churches, the local pharmacist, barbershop, grocery store and retail stores. As the individual no longer needs to pay attention to their surroundings when driving, retail stores will no longer need to form a front to the street and public engagement will be centred around the point of drop off. The urban form's evolution as MaaS becomes ubiquitous will completely change how the city has traditionally accommodated the car.

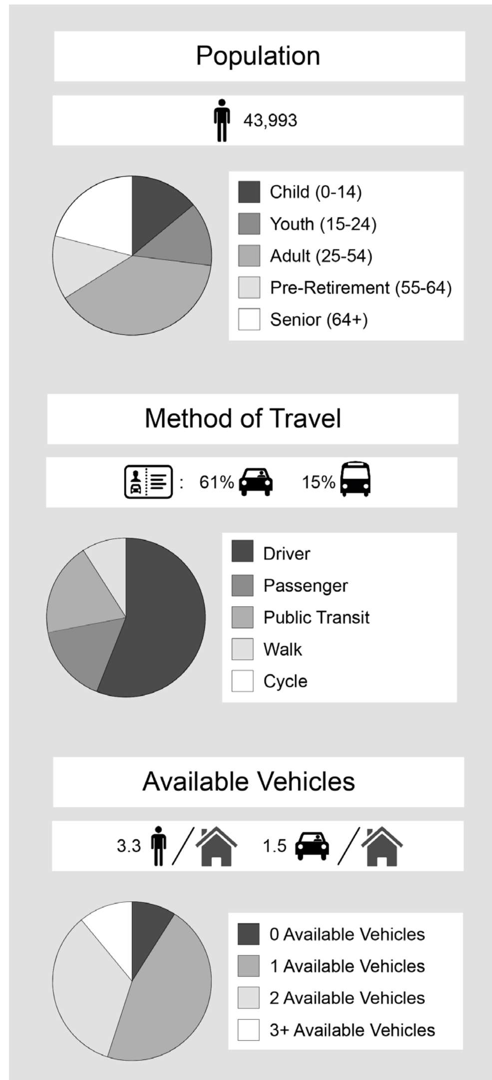


Figure 5.4 - Population statistics of L'Amoreaux taken from the Transportation Tomorrow Surey

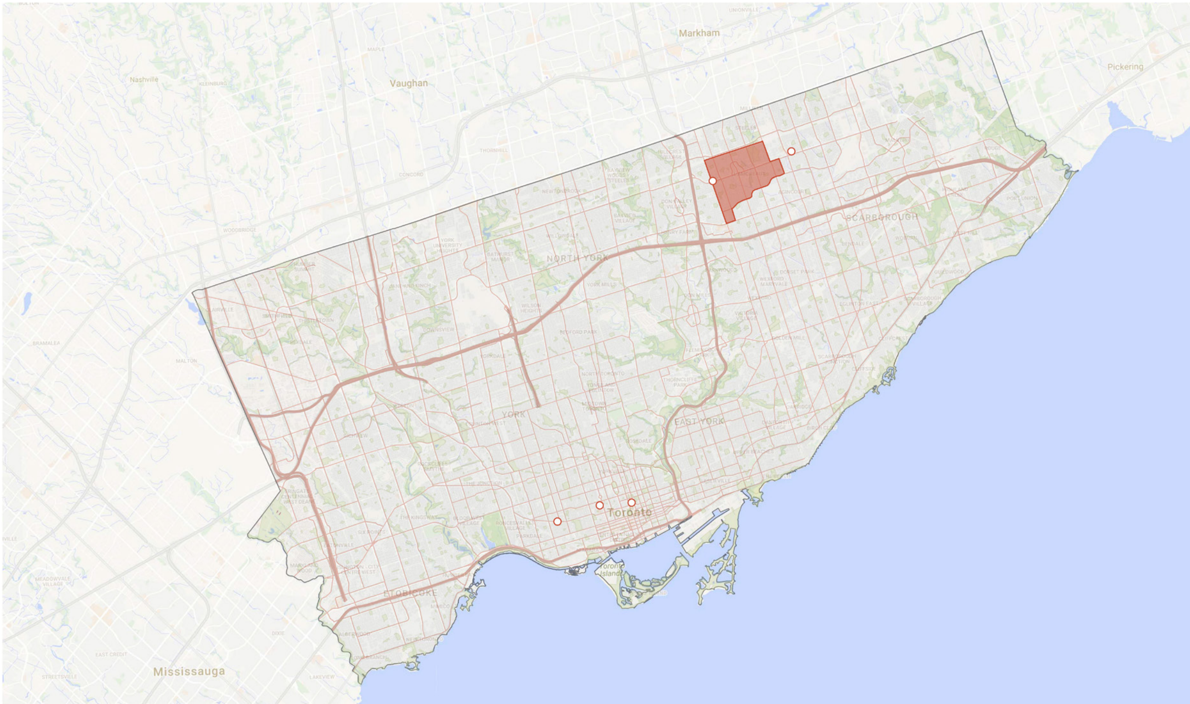


Figure 5.5 - Location of L'Amoreaux in the City of Toronto

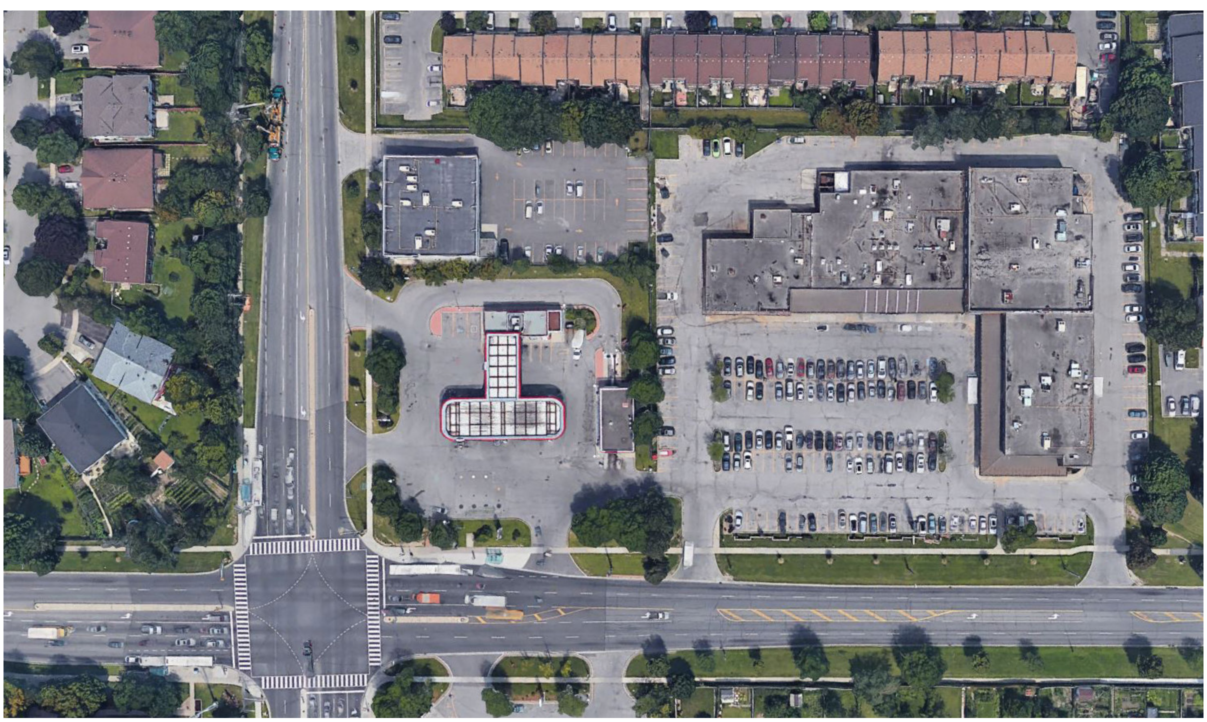


Figure 5.6 - Retail Plaza at the intersection of Finch Ave and Victoria Park Ave

Figure 5.7 - Local residents stopping by at the McDonalds to pick up food

Figure 5.8 - PetroCanada gas station located conveniently at the intersection of major intersections

Figure 5.9 - A group of friends gathering to enjoy food and drinks

Figure 5.10 - A local resident stopping by to pick up some alcohol at the LCBO

Figure 5.11 - Rear loading dock for the retail plaza

Figure 5.12 - Vast asphalt parking lot for customers of the retail plaza

Figure 5.13 - Empty church parking lot on a weekday

Figure 5.14 - Bus stop at the intersection of Victoria Park Ave and Finch Ave

The Opportunities

The current allocation of space reserved for vehicles in suburban retail plazas is extraordinarily high as a result of parking and back of house requirements. The introduction of AVs and MaaS opens the opportunity to transform many of these spaces. What was previously a temporary stop on the way to work or on the way back home can become a central community hub and gathering space for local residents.

Parking Lots: The implementation of MaaS will drastically reduce the need for parking as vehicle sharing will become the norm and ownership obsolete. The new found space can be turned into additional retail space, a public plaza for social gathering or additional green space.

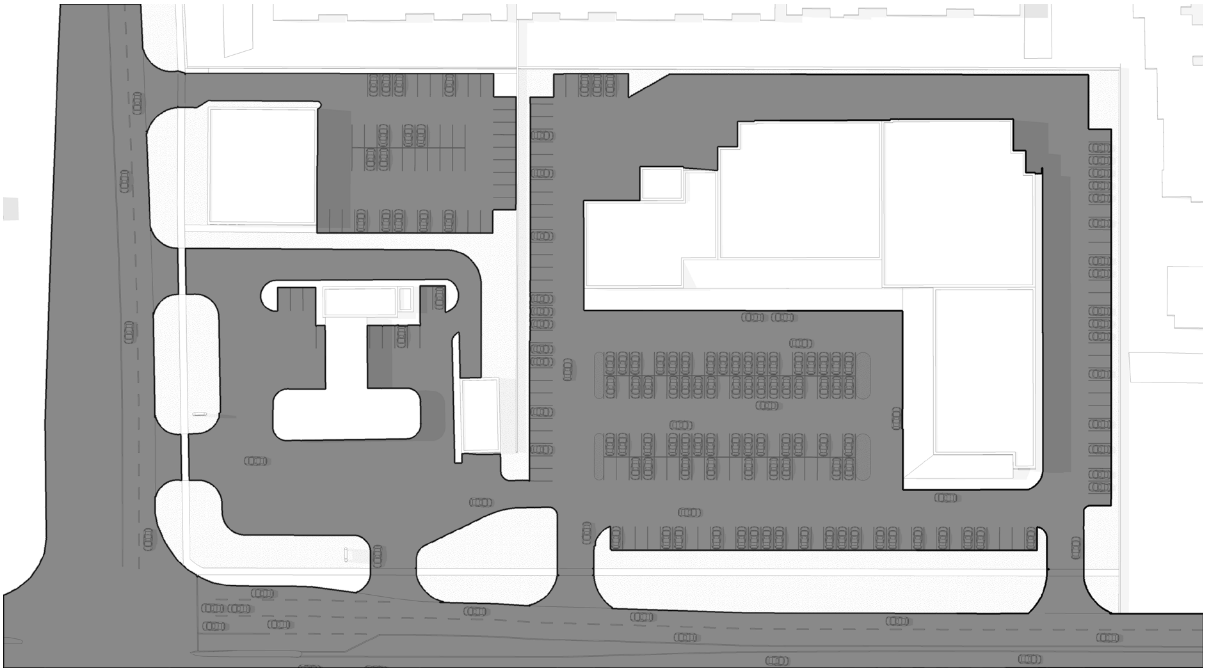
Private Parking Lots: Private parking lots for individual businesses will no longer be needed. Businesses will have more space to expand their buildings or outdoor amenity space.

Gas Stations: With the shift towards MaaS and electric vehicles, gas stations will evolve into charging and storage stations for local mobility services. These hubs will store AVs and send them to local residents when called upon.

Major Arterials: Arterials will transition into parkways as they become wholly focused on enabling mobility. Engagement towards the street will no longer be needed as passengers in vehicles no longer pay attention to their surrounding when travelling.

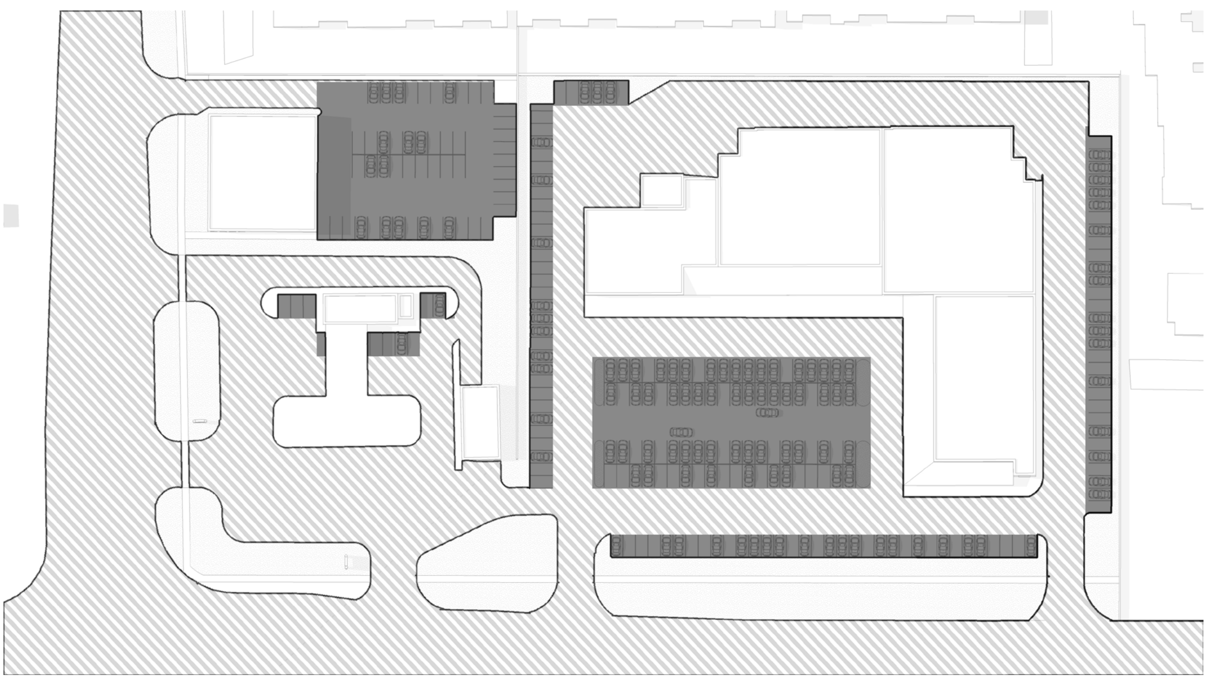
Figure 5.15 - People waiting impatiently at the Finch Ave bus stop

Figure 5.16 - A look down the 4 lane Finch Ave.



52%

Site Area Reserved for Vehicles



12%

Site Area Reserved for Parking of Vehicles

40%

Site Area Reserved for Movement of Vehicles

Figure 5.17 - Allocation of space within the retail plaza

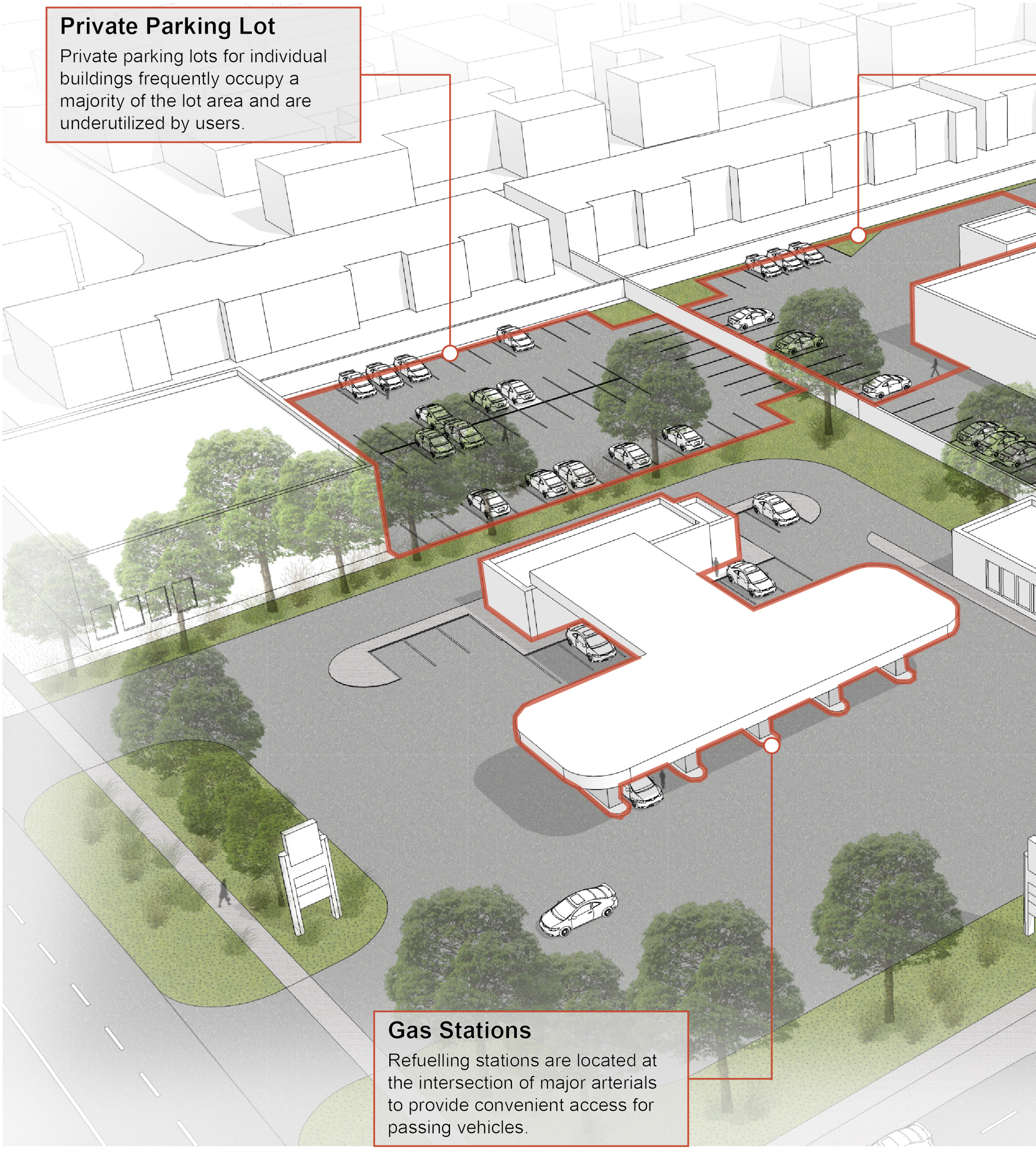
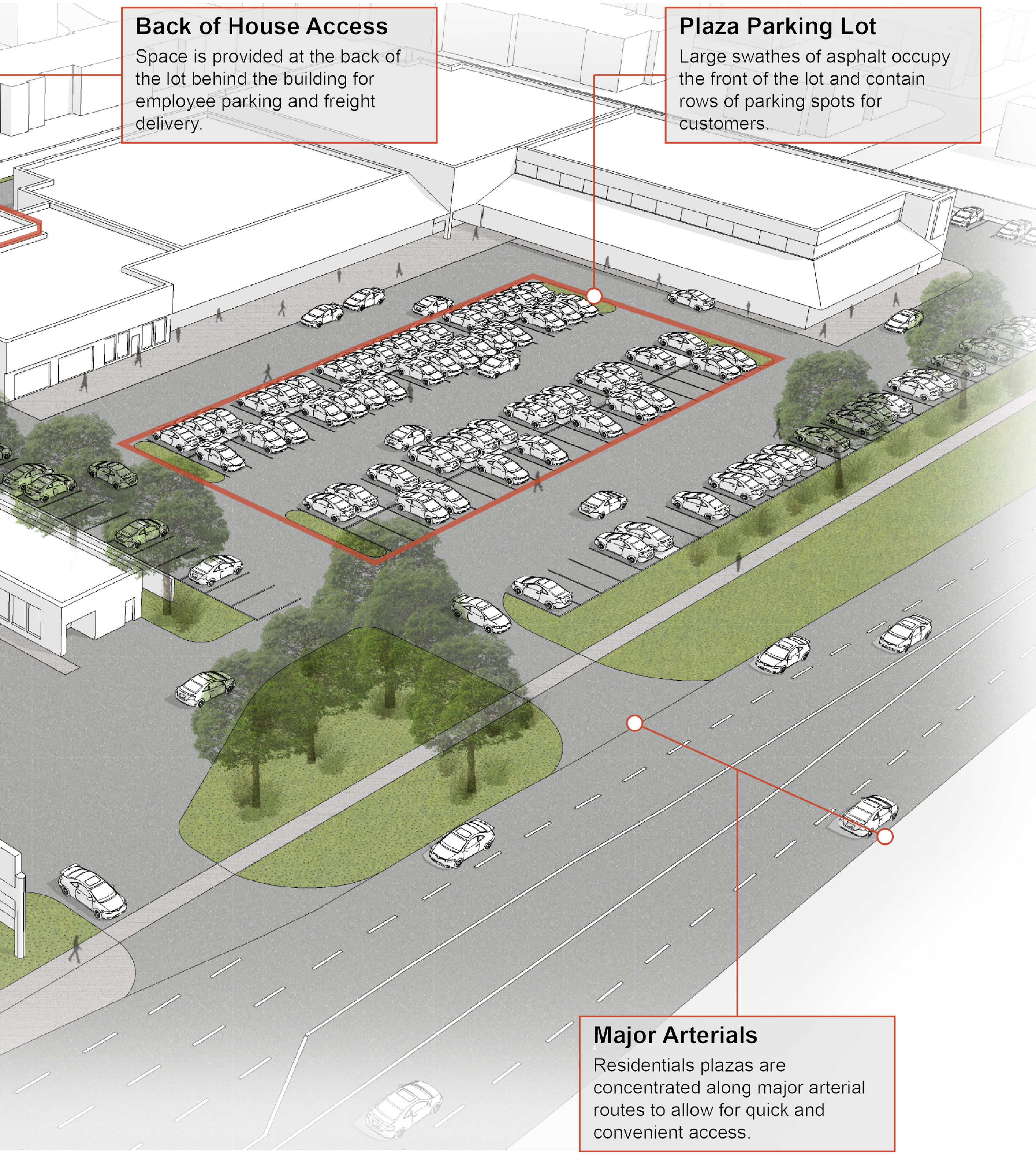


Figure 5.18 - Current layout of the retail plaza


Back of House Access
Space is provided at the back of the lot behind the building for employee parking and freight delivery.
Plaza Parking Lot
Large swathes of asphalt occupy the front of the lot and contain rows of parking spots for customers.
Major Arterials
Residentials plazas are concentrated along major arterial routes to allow for quick and convenient access.

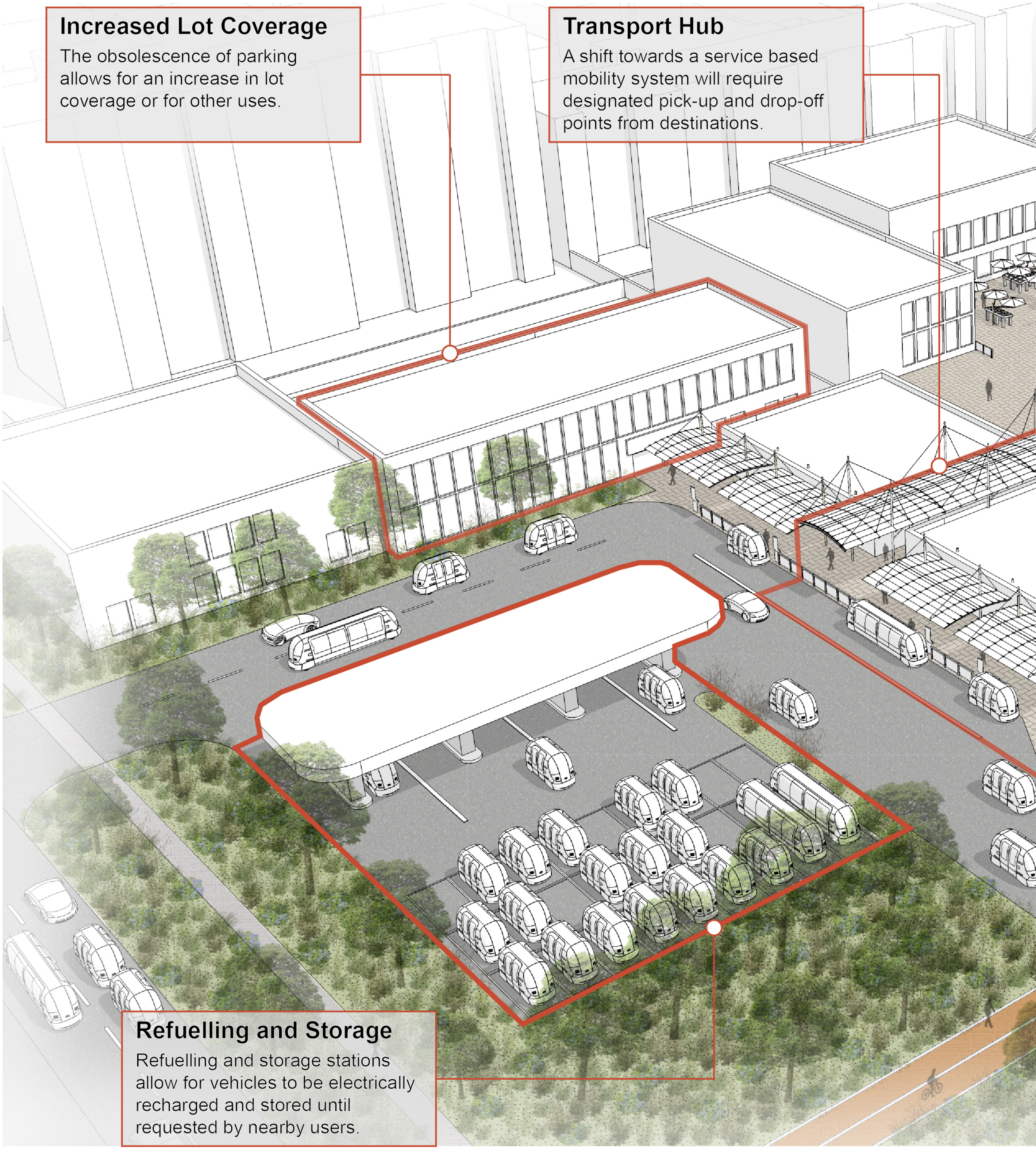
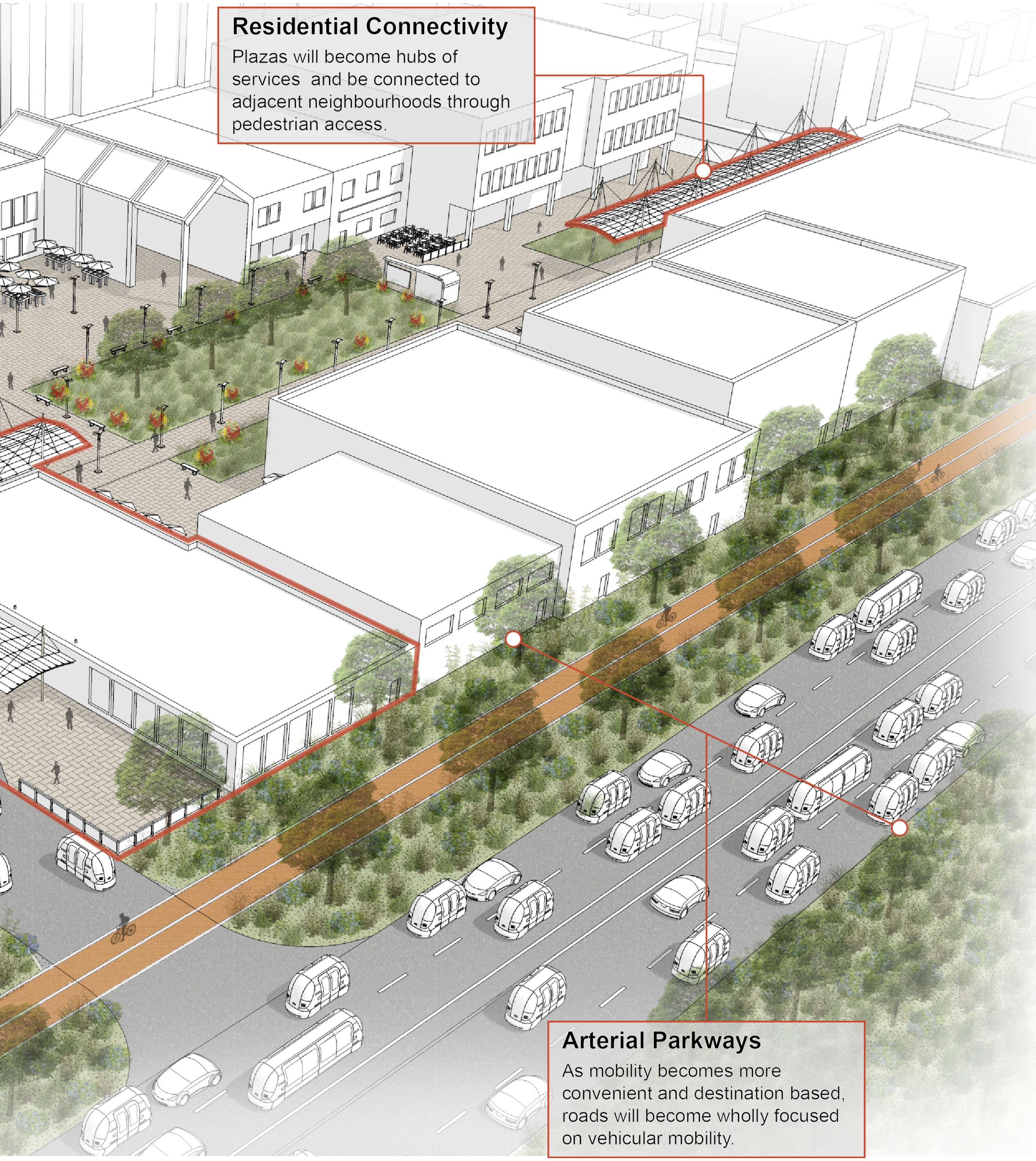


Figure 5.19 - Future layout as a result of Mobility as a Service and the ubiquity of autonomous vehicles


Residential Connectivity
Plazas will become hubs of services and be connected to adjacent neighbourhoods through pedestrian access.
Arterial Parkways
As mobility becomes more convenient and destination based, roads will become wholly focused on vehicular mobility.

05b ADAPTIVE STREETS

05b
Adaptive Streets

As the population became more addicted to automobiles during the 20th century, the formation of the city followed suit, moulding itself to support people's dependence on the car. North American cities have now become subservient to the car with extensive highways connecting the car dependent suburbs of the city. Networks of arterial roads crisscross the landscape with gas stations at their intersections to continuously fuel the city. Vast asphalt lots dot the city to enable customers to park to do their everyday business. The city has become so infatuated with enabling the car that it has choked out every other user within the city. The shift in perspective towards utilizing the street for purposes other than vehicles has already taken hold within cities. How will the introduction of AVs further change the conversation of who city streets are designed for?

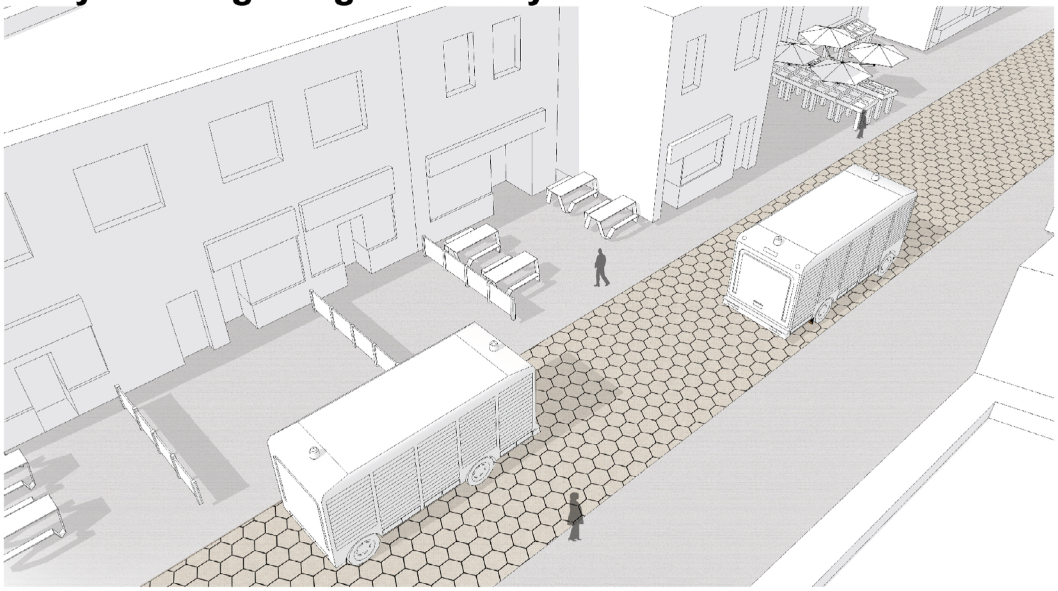
Autonomous technology can serve to actively balance the allocation of space within the city by dynamically allowing for a multitude of activities depending on the situation. The safety, efficiency and innovation the technology provides can be leveraged to allow for what was traditionally space reserved for vehicles to be transformed into bike lanes, parks, additional housing and street life. With the advent of intelligent programable vehicles, streets can transform throughout the day opening up multiple lanes of traffic during rush hour or completely disallowing vehicles on weekends. This adaptive use of valuable city space opens up the opportunity for both more efficient travel times for vehicles and a larger public realm for pedestrians. The question for the urban designers of tomorrow becomes, how does the city program its streets and roads to maximize its use? When during the day or week can AVs fully utilize the road and when are their use restricted? The prioritization of who the street is for will need to be re-evaluated as programmable AVs become more common and streets have the opportunity to dynamically adapt.

Figure 5.20 - (previous page) A look down Dundas Street

Figure 5.21 - A cyclist turns into the King Street Pilot Project

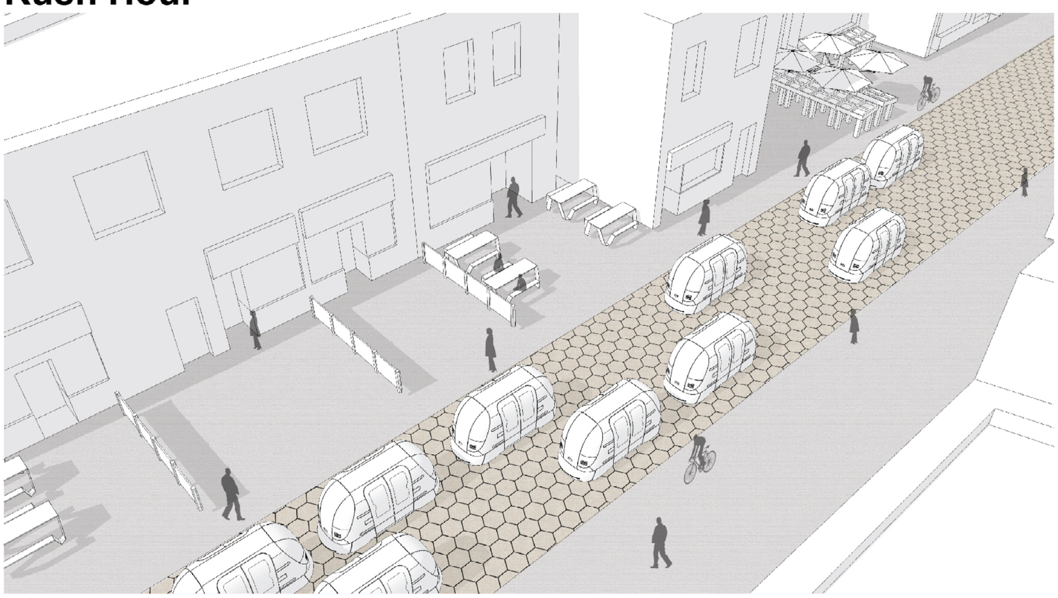
Figure 5.22 - Yonge Street closed of for Open Streets TO

Early Morning Freight Delivery



Late at night and during the early hours of the morning, the street is programmed to prioritize freight vehicles. Low pedestrian traffic facilitates the operation of autonomous freight vehicles performing deliveries. Freight delivery is concentrated mostly within these hours and is otherwise not permitted when traffic becomes busy during the day.

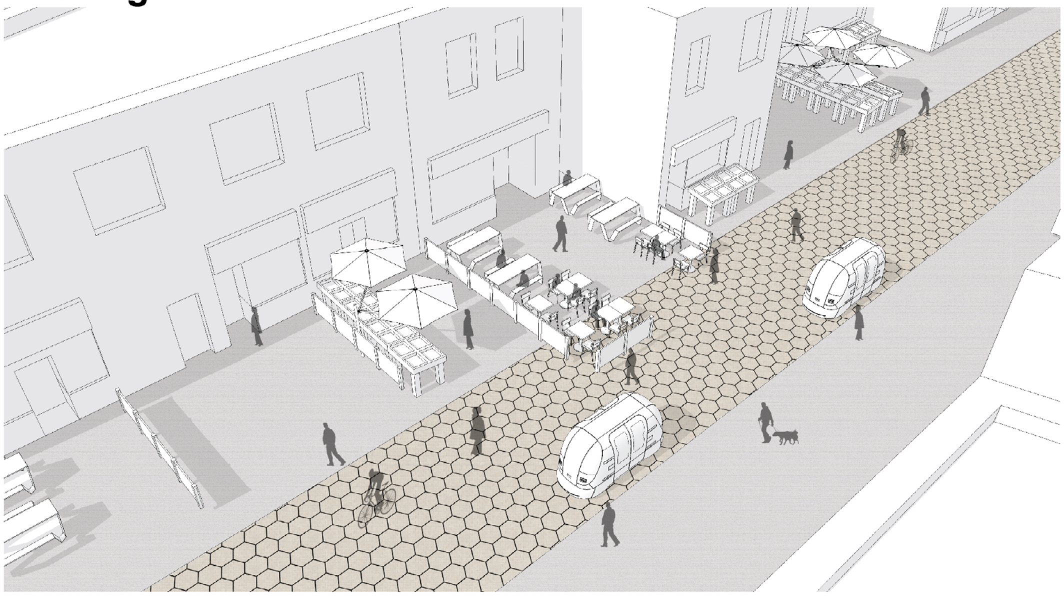
Rush Hour



From the morning rush hour to the evening rush hour, the street allows for two lanes of traffic. Both shuttle buses and single passenger vehicles are permitted at this time and operate at speeds of up to 60 km/h. It is crucial for streets to allow traffic during peak hours to allow for a smooth daily commute for the city's residents.

Figure 5.23 - Illustration of dynamic street programming

Evening



After rush hour traffic, the street narrows into only one lane of vehicle traffic and shifts toward pedestrian activity. Vehicles are forced to travel at lower speeds as the street becomes shared with pedestrians. Restaurants and retail stores push onto the street as people go out for dinner and shopping.

Weekend

On the weekends, the street prioritizes pedestrian activity, forbidding regular vehicular traffic and only allowing pedestrians,cyclists as well as public transit. Slow moving shuttles buses are permitted on the street as a means of facilitating movement along the street. Street businesses open up onto the street with food carts, restaurant patios and other street furniture. Public life and activity on the street becomes encouraged.

Little Portugal

Little Portugal is a thriving and bustling neighbourhood just outside of the downtown core of Toronto. Like many of the diverse neighbourhoods in Toronto, it is formed around a central commercial street, flanked by the residential residences of the neighbourhood. This commercial street, Dundas St, contains much of the hustle and bustle of the neighbourhood with local restaurants, offices, butcher shops, grocery stores and retail stores, all accessible to nearby residents by ways of a short walk. Accessible services in walking distance, proximity to the downtown core and a streetcar line, reduces the dependence on the automobile. Less than half of the population use the car as their primary method of travel and the average household of the neighbourhood has 0.7 cars. Although the residents of Little Portugal are not dependent on using a car, the neighbourhood suffers from a lack of space as a result of the overbearing spatial requirements of automobiles.

Commercial streets, such as Dundas St, are the heart of neighbourhoods in Toronto and the ability to dynamically program these streets with the introduction of AVs will allow these streets to better serve their community. Throughout the day, Dundas street plays multiple roles from a major city thoroughfare during rush hour to a bustling street for dining during evenings. The street is also home to many urban festivals and events throughout the year. The introduction of adaptable streets will allow the city to both fulfill the traffic needs of a busy city, opening up multiple lanes during rush hour, as well as enable the street to become a community center, through pedestrian only access during events or weekends. This adaptability can also be adjusted according to seasons with increased pedestrianization during the hot summers and less during the winters as restaurant patios are no longer in use. The intelligent and dynamic use of the street enabled by AVs will utterly revolutionize the static nature of streets today.

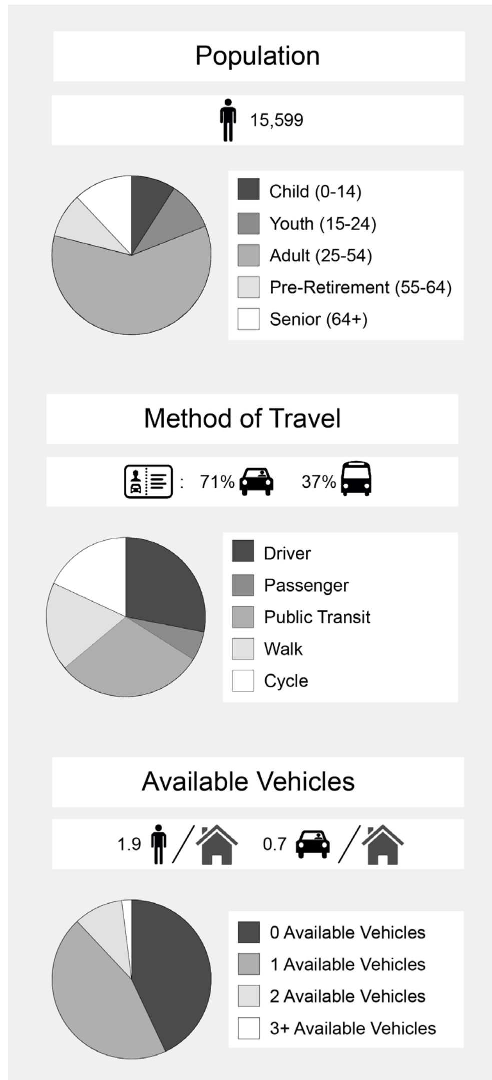


Figure 5.24 - Population statistics of Little Portugal taken from the Transportation Tomorrow Survey

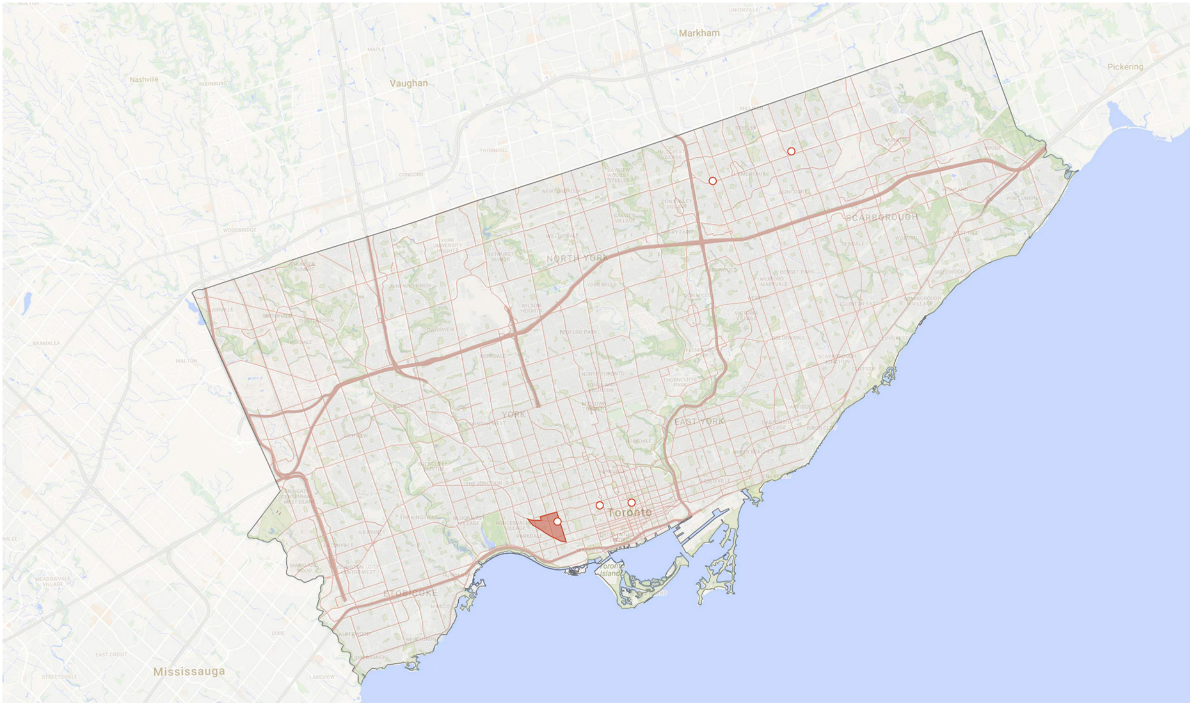


Figure 5.25 - Location of Little Portugal in the City of Toronto

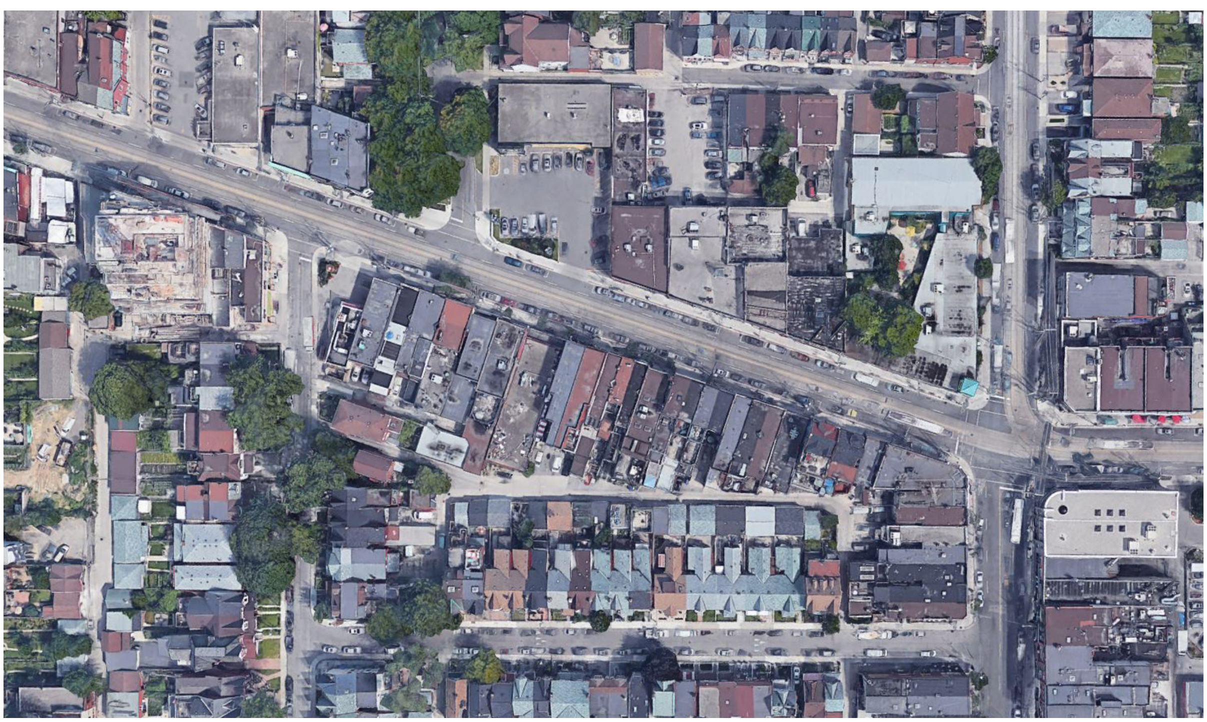


Figure 5.26 - Finch Street at Ossington Ave

Figure 5.27 - A hot dog stand tucked into a vacant lot

Figure 5.28 - Lakeview Avenue Parkette

Figure 5.29 - Patio Space in front of the local pub

Figure 5.30 - Dundas Street

Figure 5.31 - Delivery truck parked over the sidewalk

Figure 5.32 - Parking lot for Beer store customers

Figure 5.33 - Cars tucked into every available space

Figure 5.34 - Delivery van unloading in the rear laneway

The Opportunities

Commercial streets today are wrestling to balance what little space is available to the multiple demands placed on it by local residents. Pedestrian sidewalks are squeezed by the need to accommodate lanes of traffic and street parking. Parking lots for private businesses fight against the need for green public space in the community. Restaurants try to squeeze in patio space and retail shops try to place signage in what little space is left available on the sidewalk. There just isn't enough space leftover after what is allocated for automobiles. The ability to program streets and have AVs actively adapt to this programming will allow for more temporary and dynamic use of space within these critical streets.

Private Parking Lots: Private parking lots for individual businesses can be transformed into a public plaza, providing event space, a place for socializing in the community and additional green space

Back of House Parking: Employee parking and garages can be turned into additional retail space for stores or renovated into medium density housing.

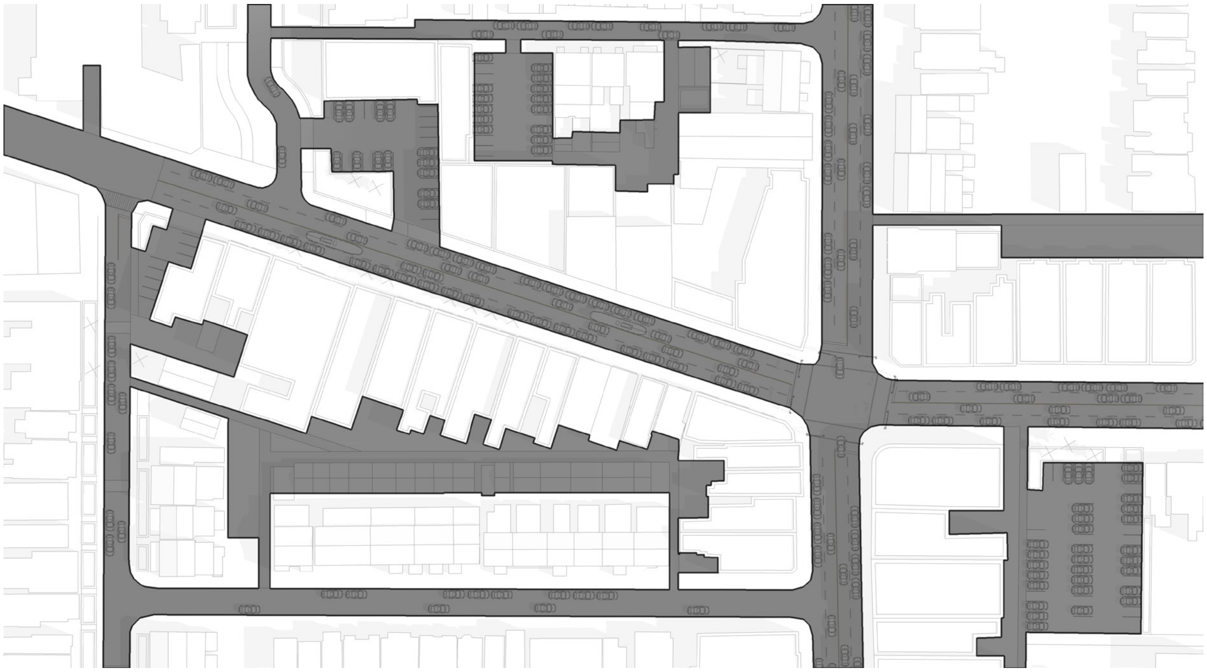
On-Street Parking: On-street parking will become obsolete allowing for stores to push out onto the street and have more available space to engage pedestrians through patios, signage or merchandise.

Public Parking Lots: Green P parking lots, which provide parking for nearby retail stores, would be transformed into AV storage hubs to ensure on-demand access at all times.

Street Design: Through different paving and street designs, the primary function of the street as well as the different sections of the street can be better communicated and programmed.

Figure 5.35 - Patio furniture outside the local cafe

Figure 5.36 - Convenience store showing merchandise outside on the sidewalk



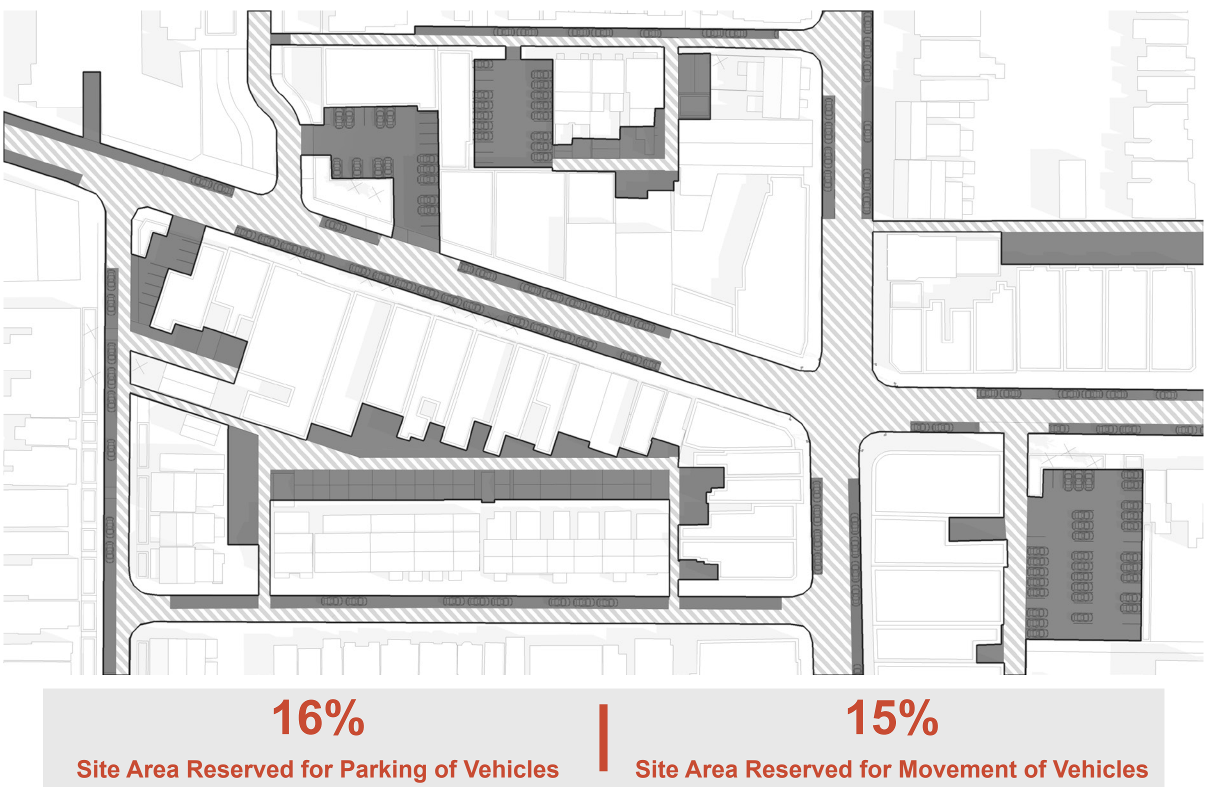


Figure 5.37 - Allocation of space along the commercial street

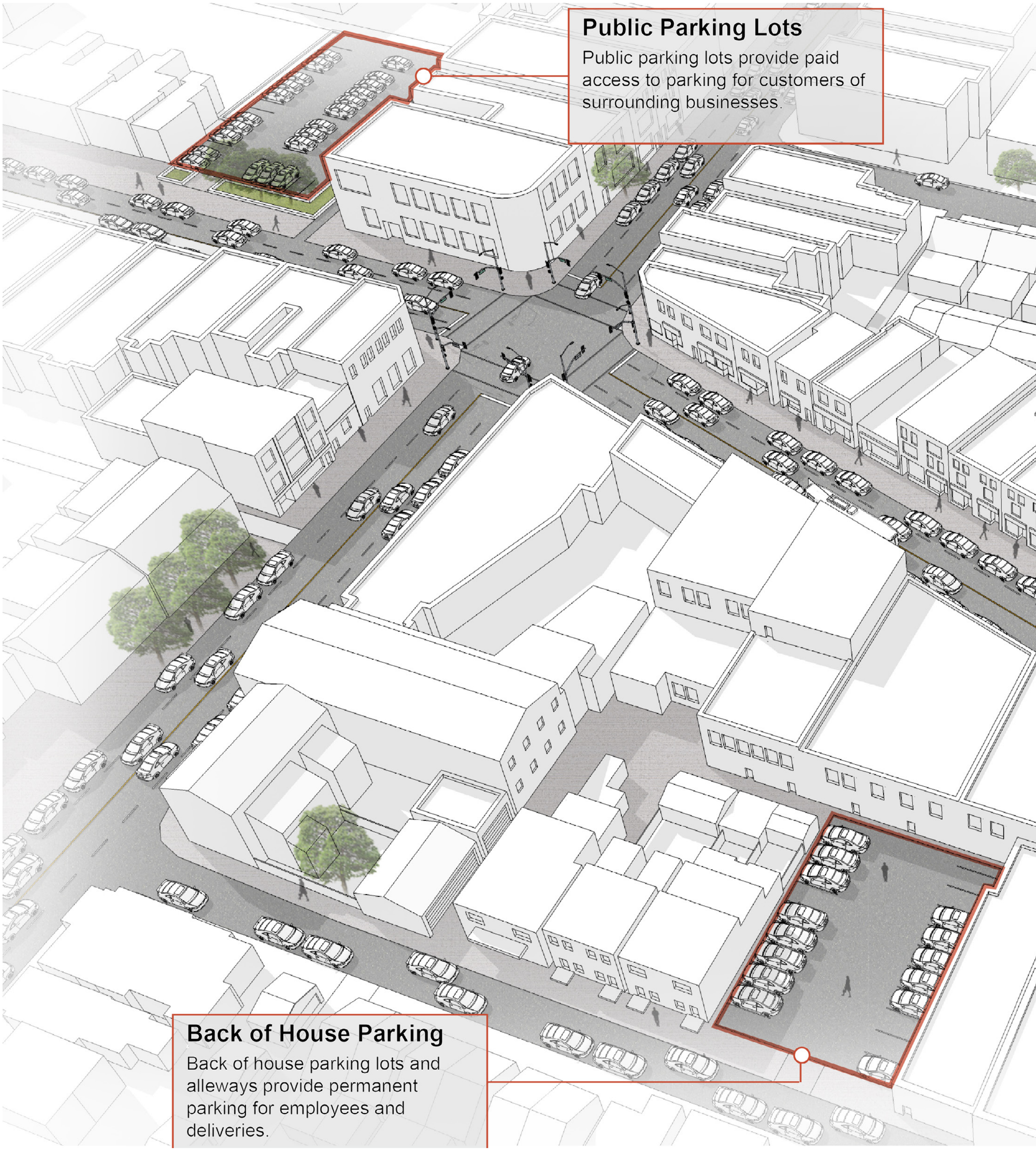
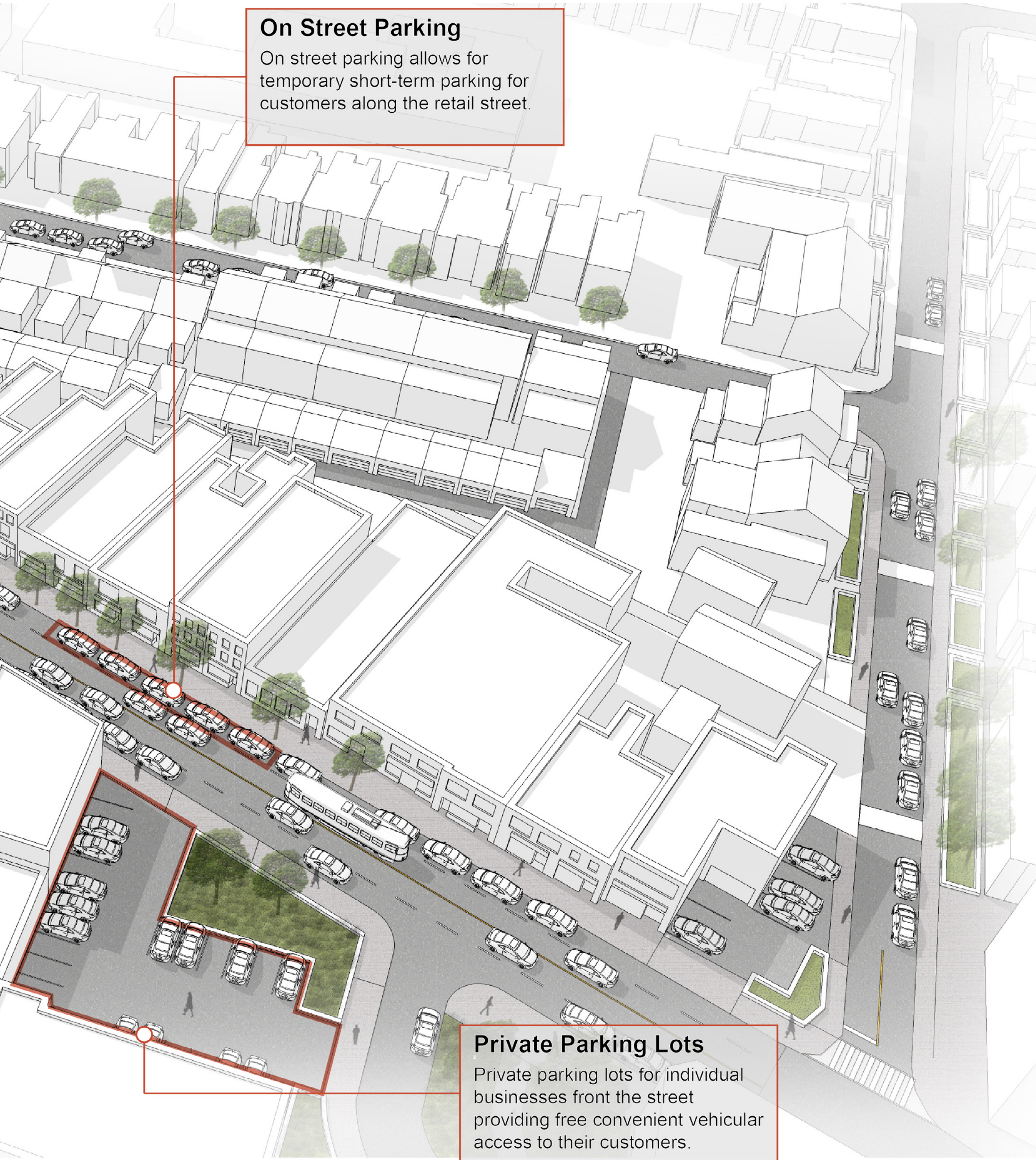


Figure 5.38 - Current layout of Dundas Street


On Street Parking
On street parking allows for temporary short-term parking for customers along the retail street.
Private Parking Lots
Private parking lots for individual businesses front the street providing free convenient vehicular access to their customers.

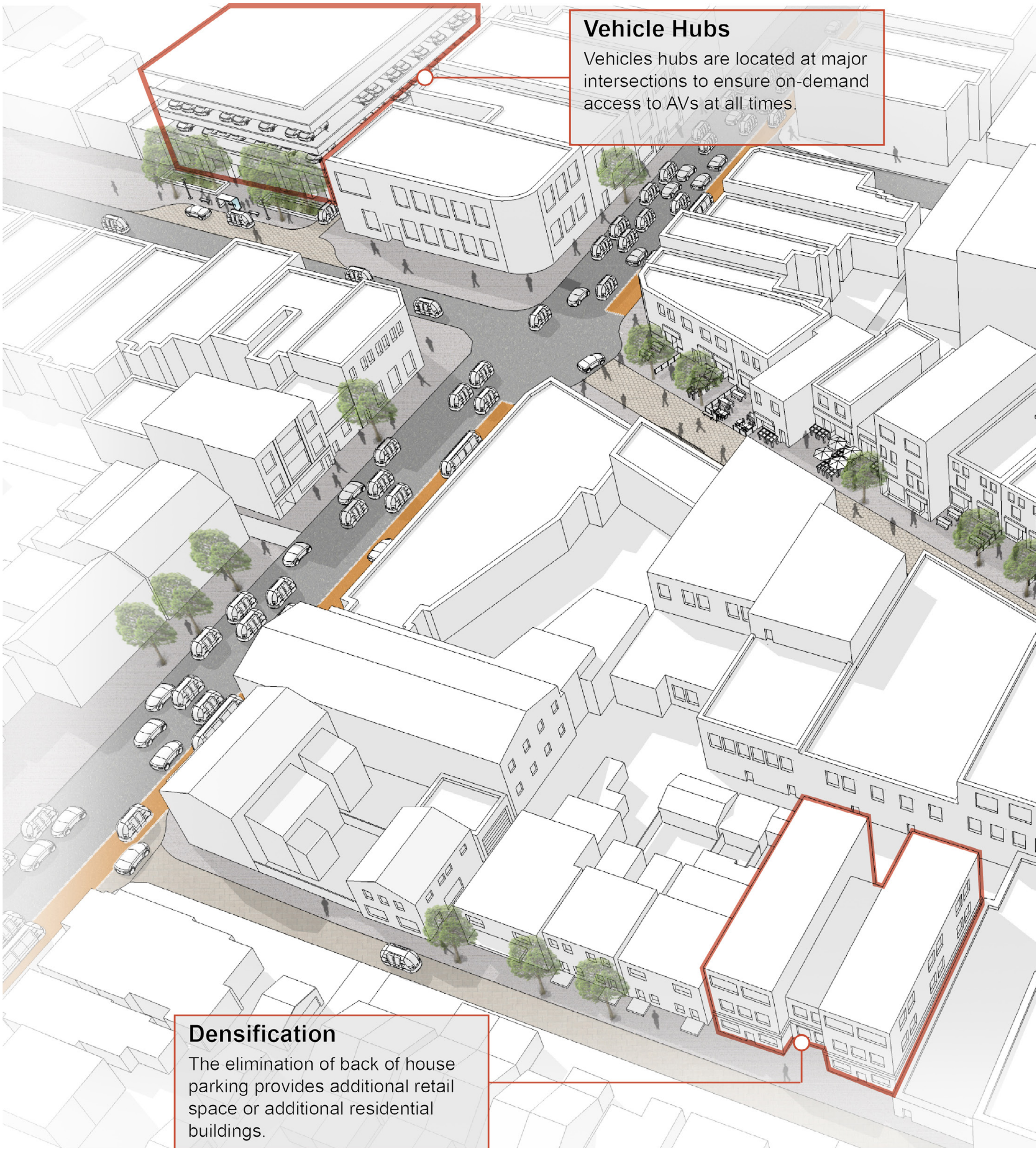
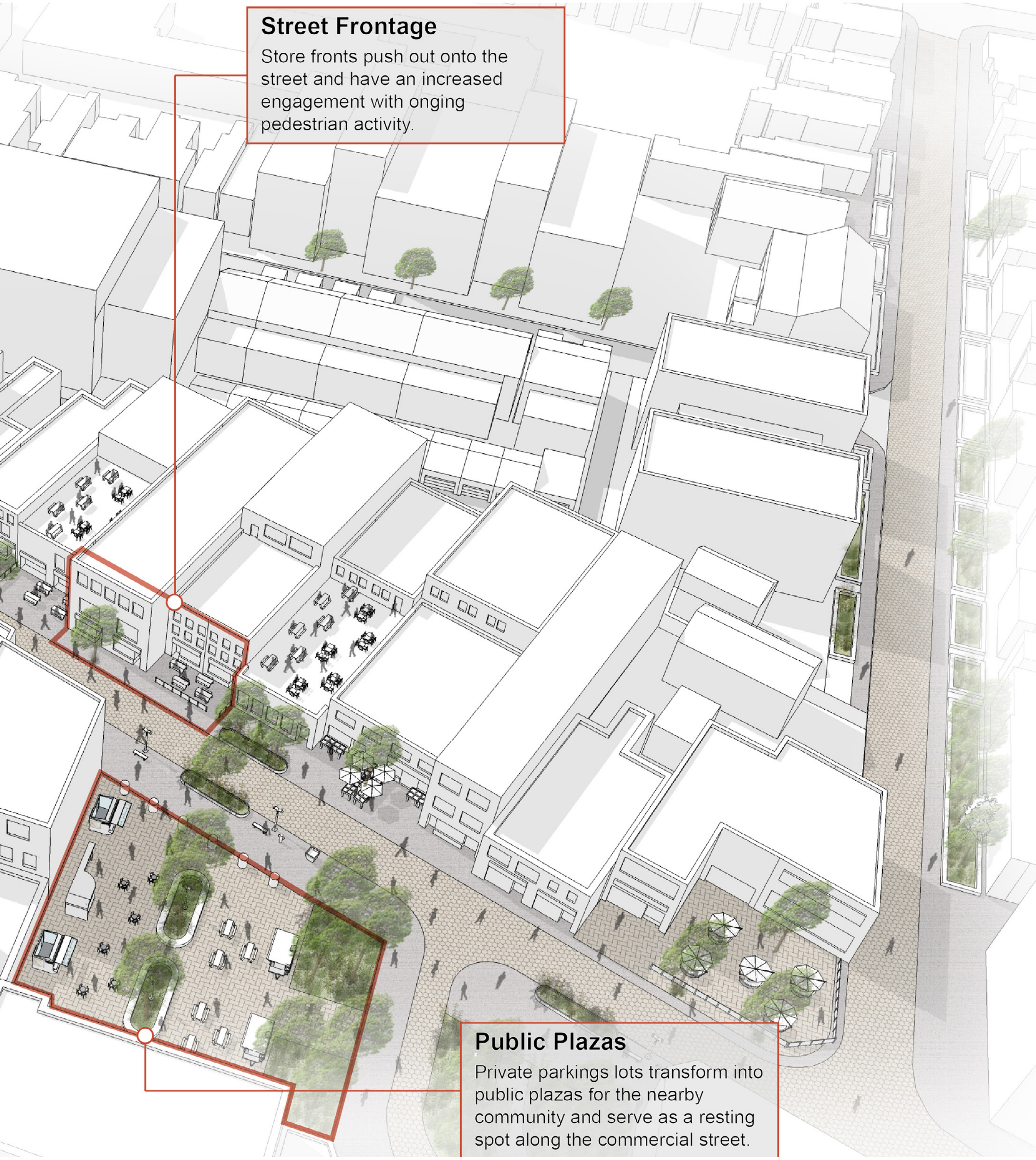
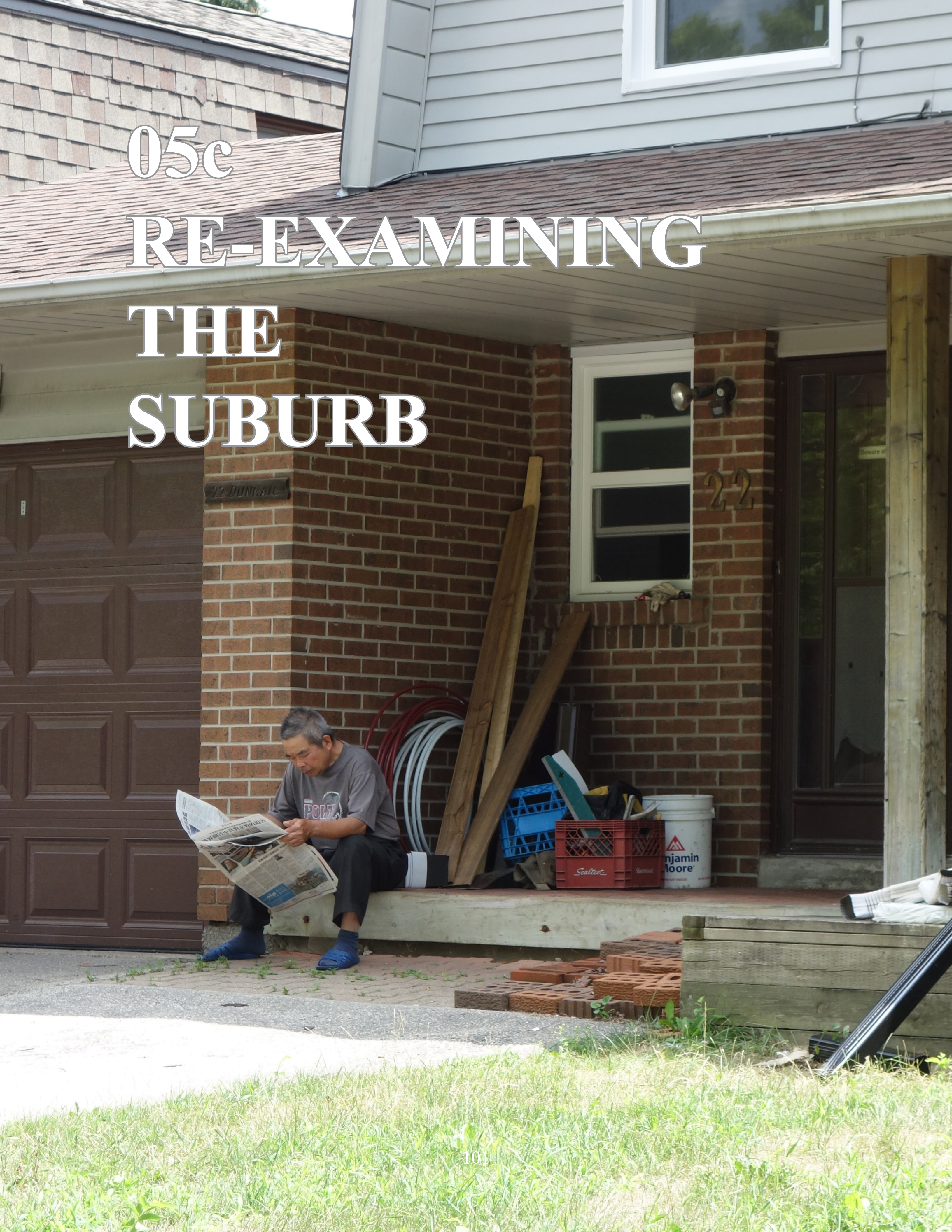


Figure 5.39 - Potential future layout of Dundas street on a weekend when automotive traffic is restricted


Street Frontage
Store fronts push out onto the street and have an increased engagement with onging pedestrian activity.
Public Plazas
Private parkings lots transform into public plazas for the nearby community and serve as a resting spot along the commercial street.

05c RE-EXAMINING THE SUBURB



05c
Re-examining the Suburb

Suburban living has become an extricable part of North American cities, promising individuals and families respite from the hectic everyday life of the bustling city. The concept of the suburb is wholly enabled by the power, speed and convenience of the automobile, which is reflected in the structure and organization of suburban housing. Suburban houses line up along stretches of asphalt, solely reserved for vehicular access to each individual house. Residential lots devote large portions of the land for driveways and garages, which end up forming the face of the street. Residents are frequently seen using what space is left for other activities, such as play or social relaxation, but the car remains king, forcing other activities to give way.

The introduction and wide spread use of autonomous vehicles opens the opportunity to challenge the inherent structure of present day suburban neighbourhoods. The drastic reduction in personally owned vehicles, increased safety of autonomous vehicles and increased efficiency of autonomous vehicles will liberate vast amounts of space previously allocated for automobile use. Residents will then need to face the question of how best to take advantage of the newly available space. Will houses renovate garages into an extra room for the family? Perhaps, taking advantage an obsolete driveway, medium density housing can be built with the extra space. The needs of the automobile forcefully shaped the formation of the suburban home during the middle of the 20th century, but the advent of autonomous technology will be able to redefine the inherent rules of the suburb and produce a wholly new way of residential living.

Figure 5.40 - (previous page) Reading the paper on a summer day

Figure 5.41 - A typical snout house in suburban Toronto

Figure 5.42 - A massive driveway in front of a house to park multiple vehicles

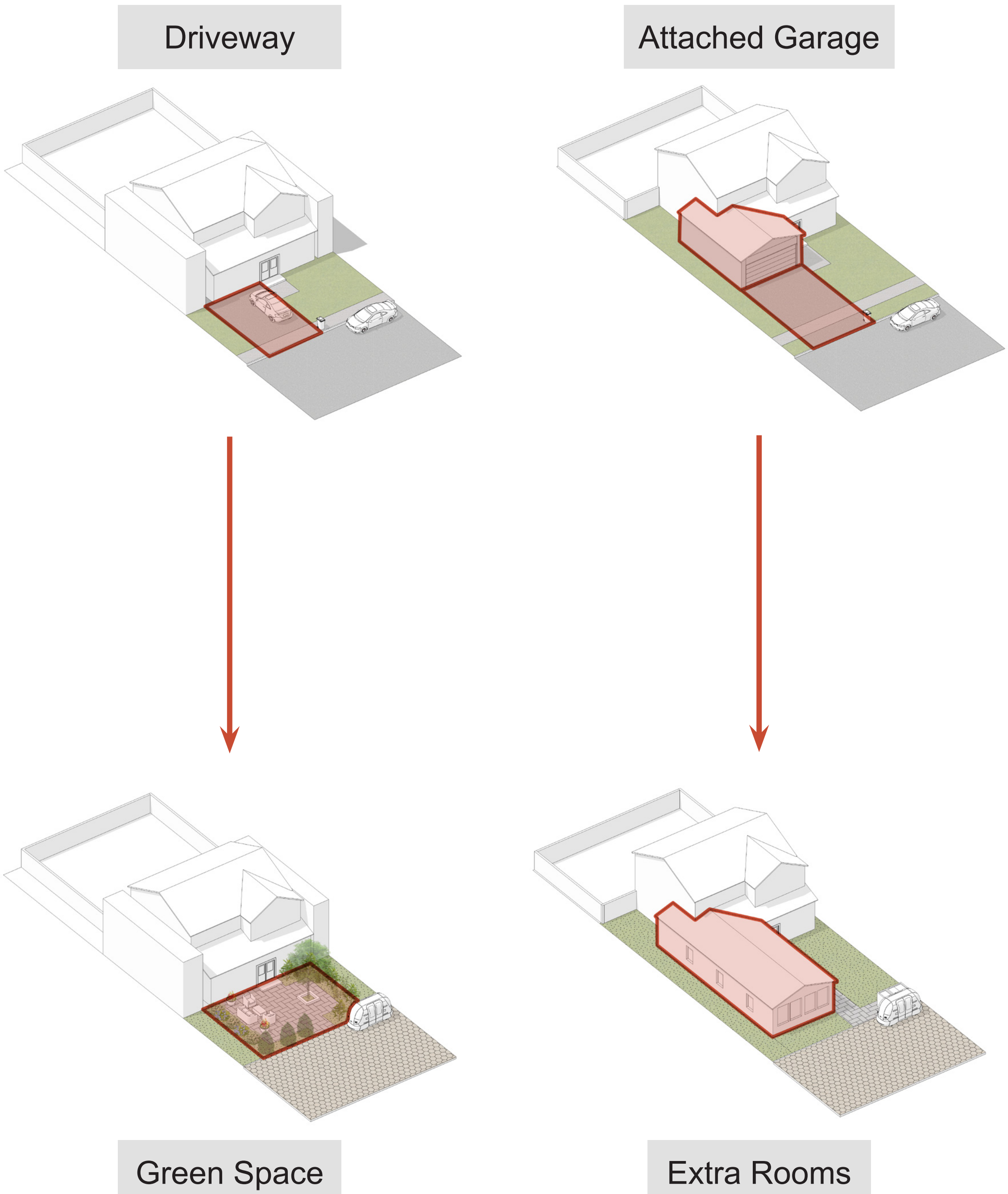


Figure 5.43 - Illustration of the various possibilities utilizing the space of garages and driveways

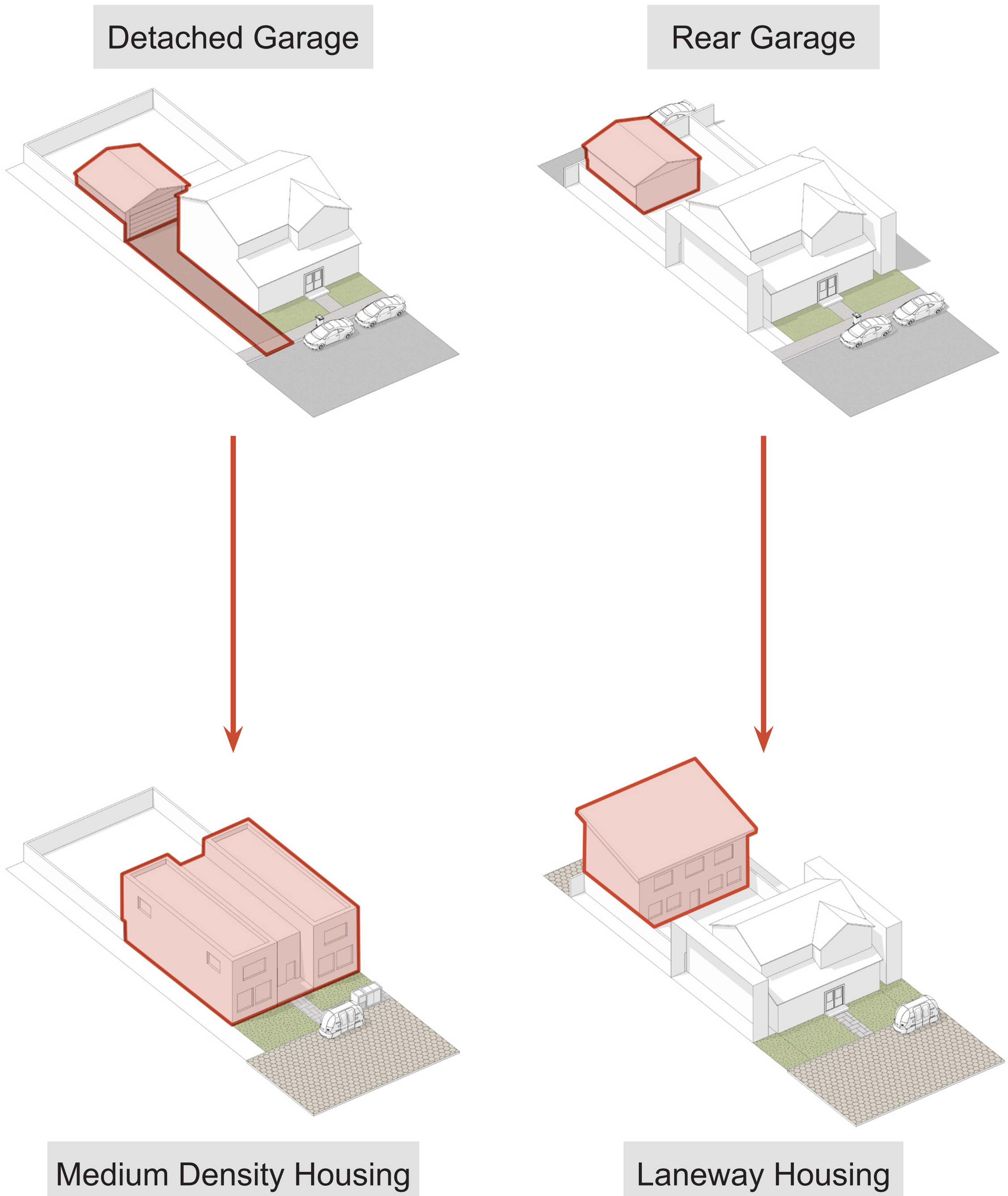

Detached Garage
Rear Garage
Medium Density Housing
Laneway Housing

Figure 5.44 - Possible future layouts of suburban neighbourhoods enabled by AVs

Courtyard Neighbourhood

Green Belt Neighbourhood

Agincourt North

Suburban life in Toronto is focused on housing many of the city's families and providing them with their own personal part of the city to live their lives. The neighbourhood of Agincourt North, located in the north-east of Toronto, follows this trend, having the highest percentage of children, youths and seniors within their populations. Being so far separated from the city core and other services, the dependence on the car is also one of the highest with nearly 75% of residents using a car as their preferred method of transport. The residents of the neighbourhood have on average 1.4 available vehicles per household, with half of the households having 1 available vehicle and a quarter of the household having 2 available vehicles. Suburban living is inextricable tied to the use of cars and that close relationship is reflected in the generous amounts of space allocated for cars in each residential lot.

The introduction of autonomous vehicles and the shift towards Mobility as a Service will render obsolete the garage and driveway as well as open up the road to activities other than solely the movement of vehicles. Residential garages, no longer needed to store cars, could potentially be renovated into a workshop, an office or an additional bedroom. Driveways could be repaved into gardens, patios or a space for children to play. Streets can narrow, allowing for social space shared amongst neighbours to appear or for houses to expand closer to the street. The elimination of personally owned vehicles as a result of autonomous vehicles will allow for a greater degree of customization for the suburban house.

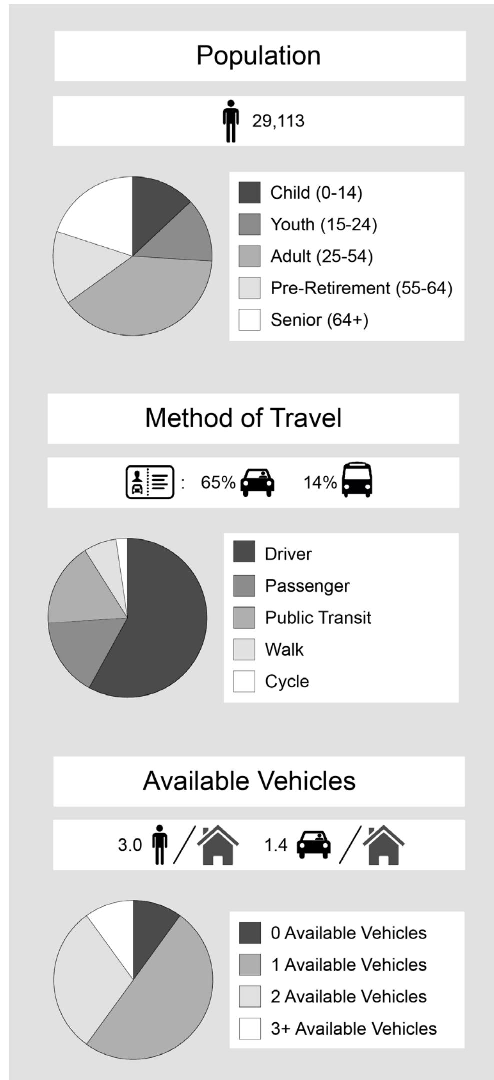


Figure 5.45 - Population statistics of Agincourt North taken from the Transportation Tomorrow Survey

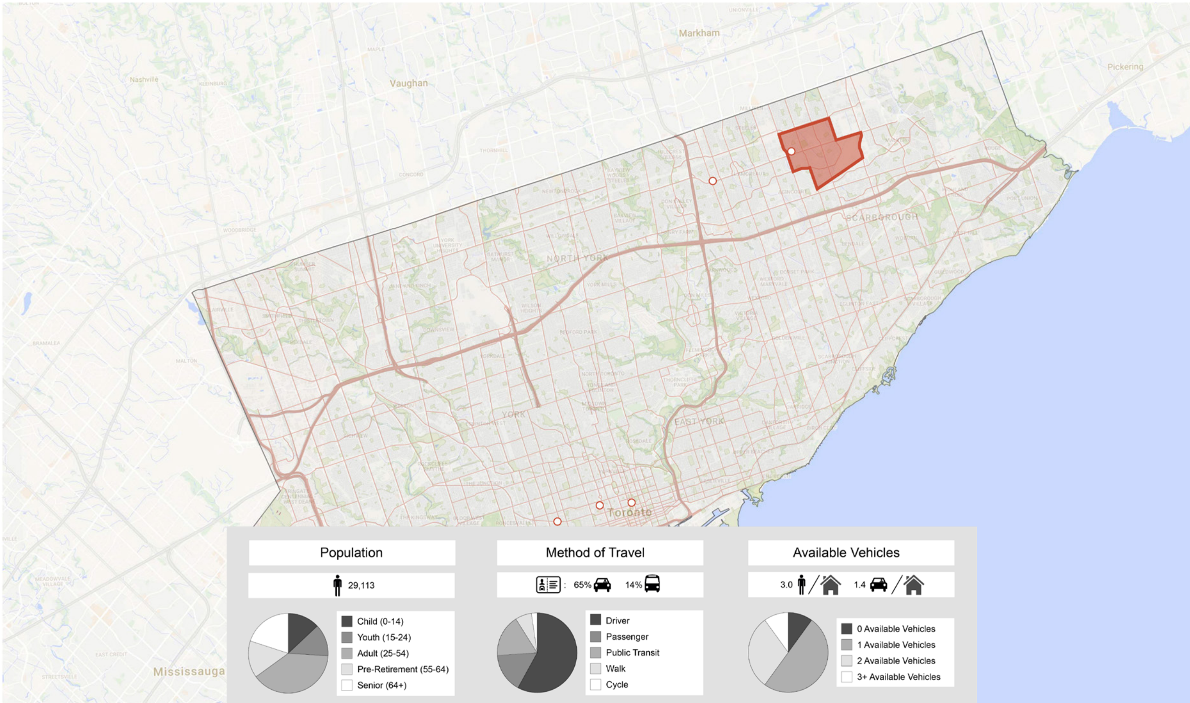


Figure 5.46 - Location of Agincourt North in the City of Toronto

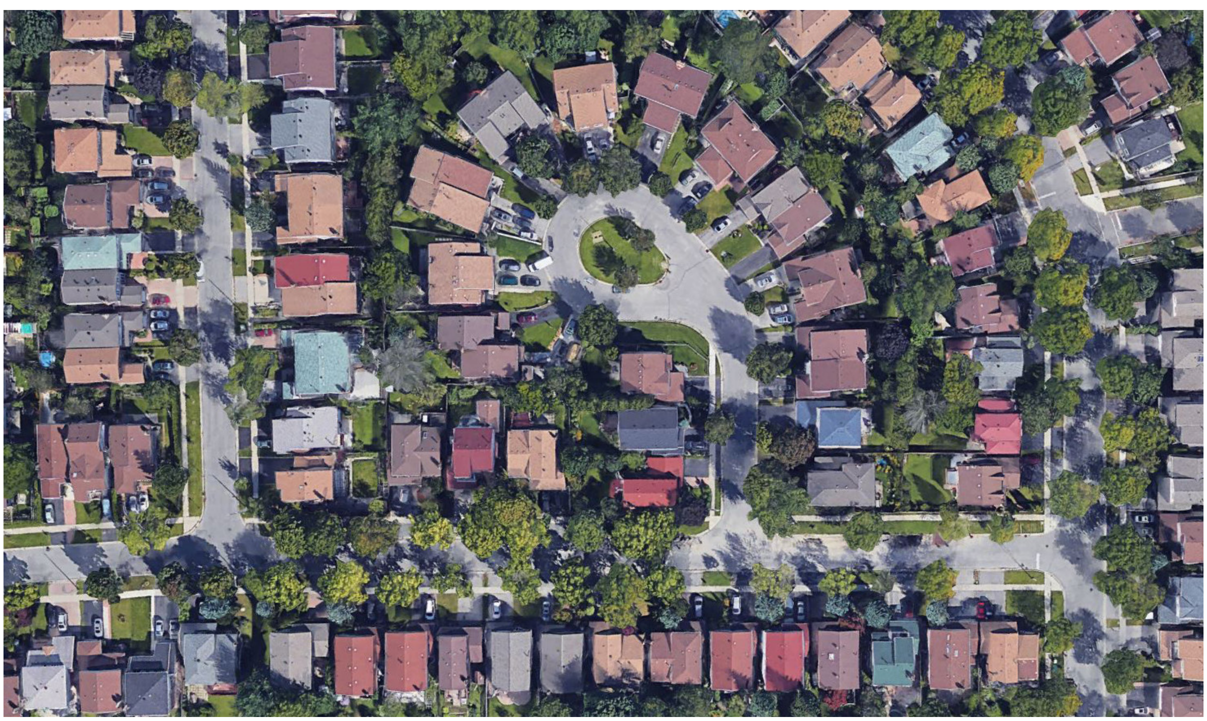


Figure 5.47 - Aerial view of a suburban neighbourhod in Agincourt North

Figure 5.48 - A typical suburban street

Figure 5.49 - A cul-de-sac within the neighbourhood

Figure 5.50 - Pastoral view walking down the sidewalk

Figure 5.51 - A luscious garden beside an empty asphalt driveway

Figure 5.52 - A man reading the newspaper on his porch

Figure 5.53 - Garbage bins blocking the use of a basketball net in the cul-de-sac

Figure 5.54 - Seating placed in one of the few paved areas not for vehicles

Figure 5.55 - An asphalt driveway packed with parked cars

The Opportunities

The driveway and garage often take up as much as one third of the whole residential lot, limiting designated space for other activities such as play or relaxation. Residents of the suburban neighbourhood will be able to better customize their home and express themselves as more space becomes available.

Garages: The garages of homes will be renovated into workshops, offices and bedrooms as needed by residents. Houses will be able to better support the requirements of family life.

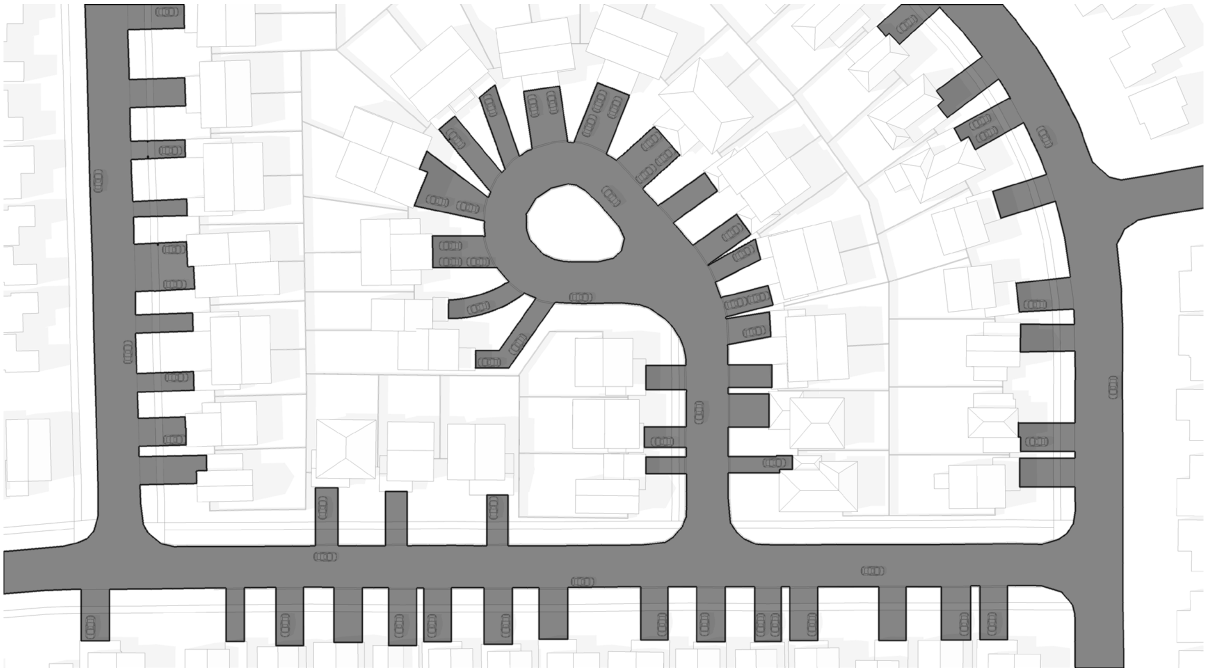
Driveways: Driveways could be repaved and landscaped into patio space, seating areas or gardens in front of homes. The free space could also be built over to make way for higher density housing.

Cul-de-sacs: Cul-de-sacs could be transformed into a communal recreation area for sports, gardening or social activities.

Community space: The reduction in road width can allow for the emergence of shared public areas for the entire neighbourhood.

Figure 5.56 - A small sunroom with seating

Figure 5.57 - A carefully manicured front lawn and garden



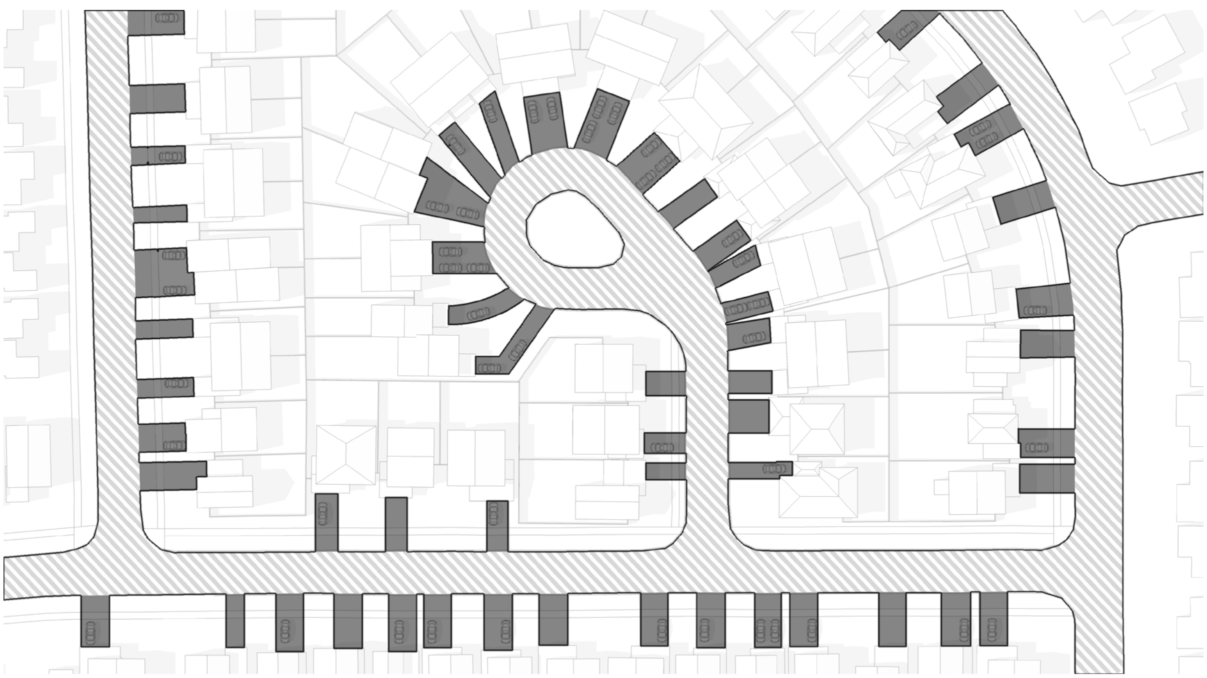


Figure 5.57 - Allocation of space in the suburb

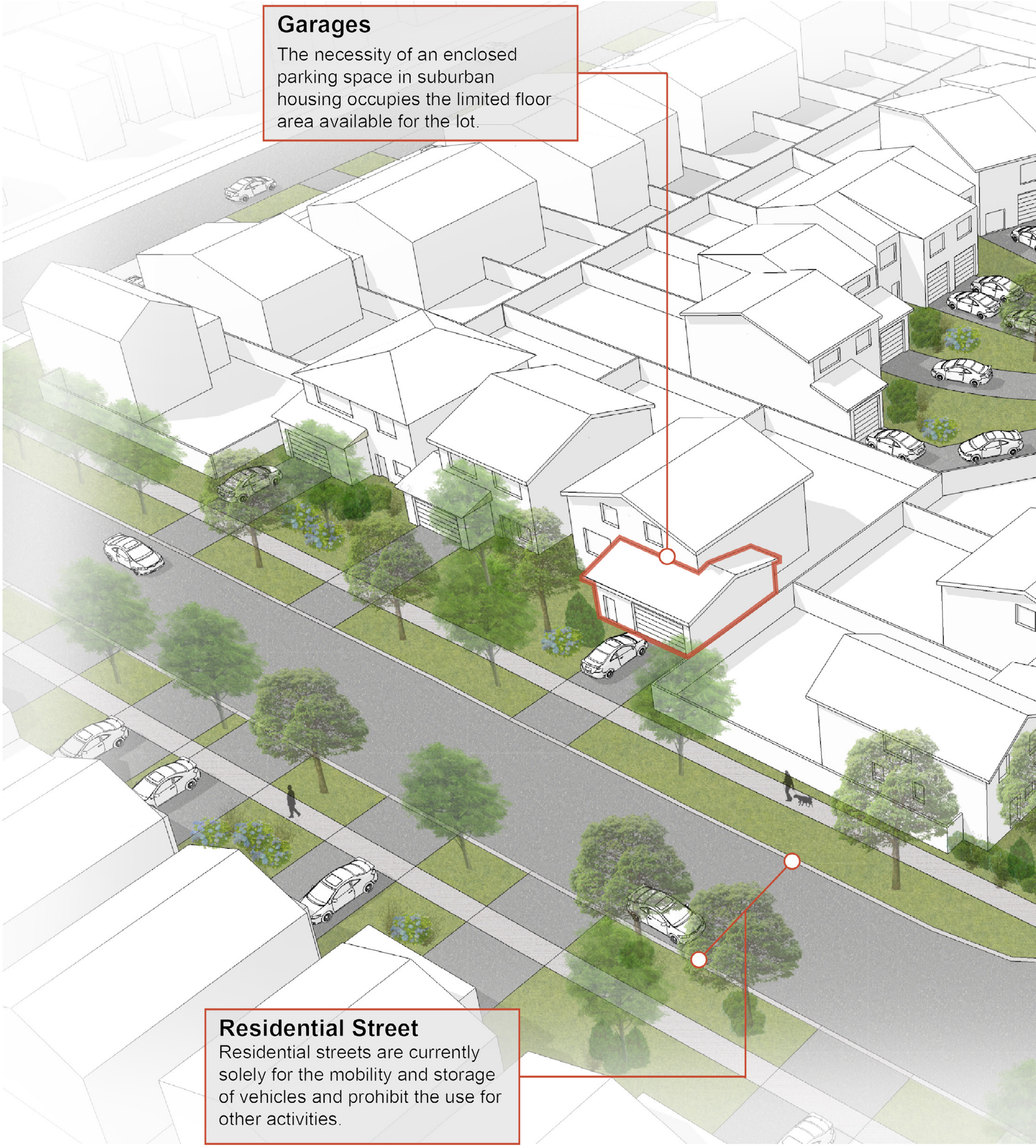
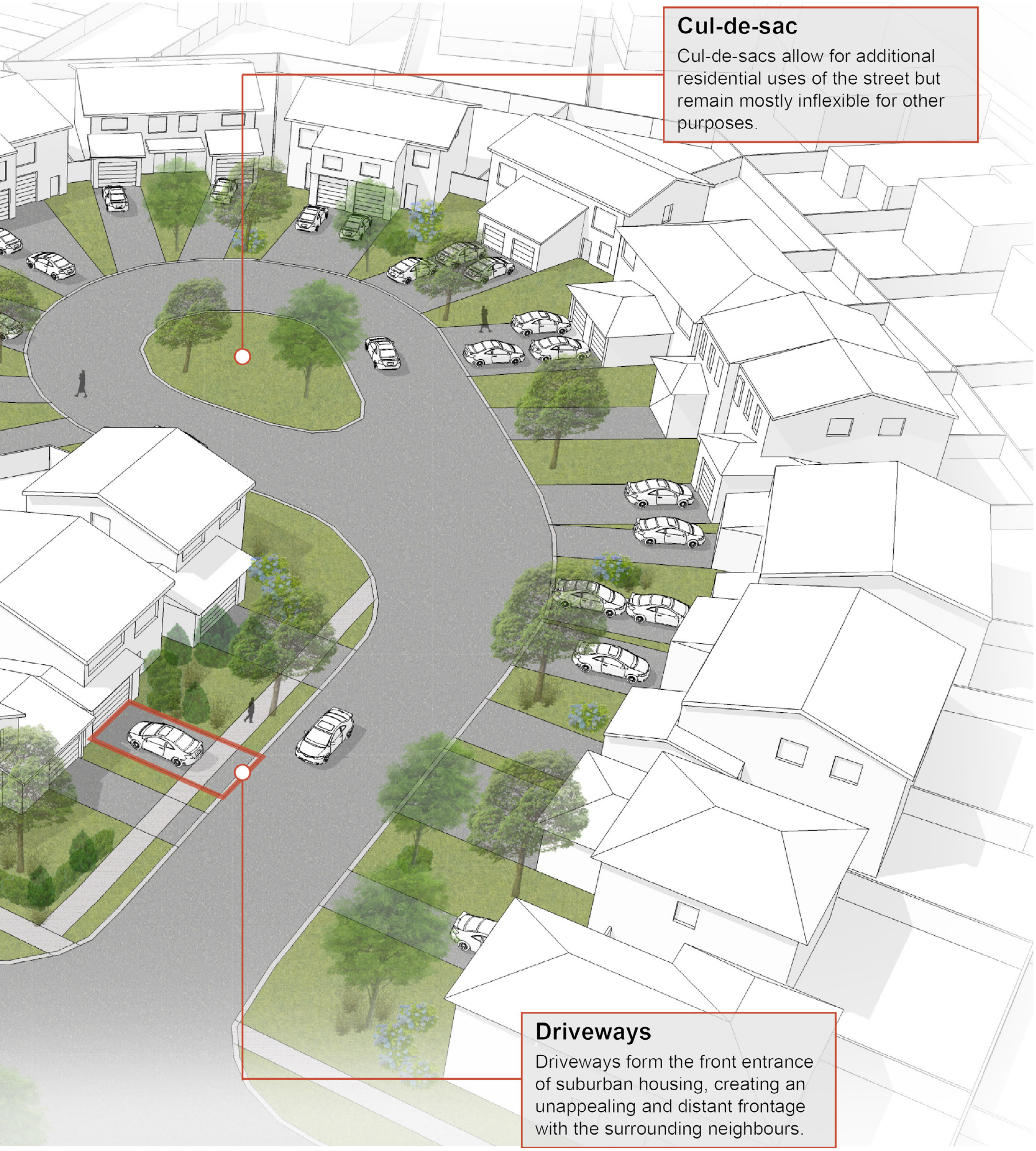


Figure 5.58 - Current layout of a typical suburban neighbourhood



Cul-de-sac
Cul-de-sacs allow for additional residential uses of the street but remain mostly inflexible for other purposes.
Driveways
Driveways form the front entrance of suburban housing, creating an unappealing and distant frontage with the surrounding neighbours.

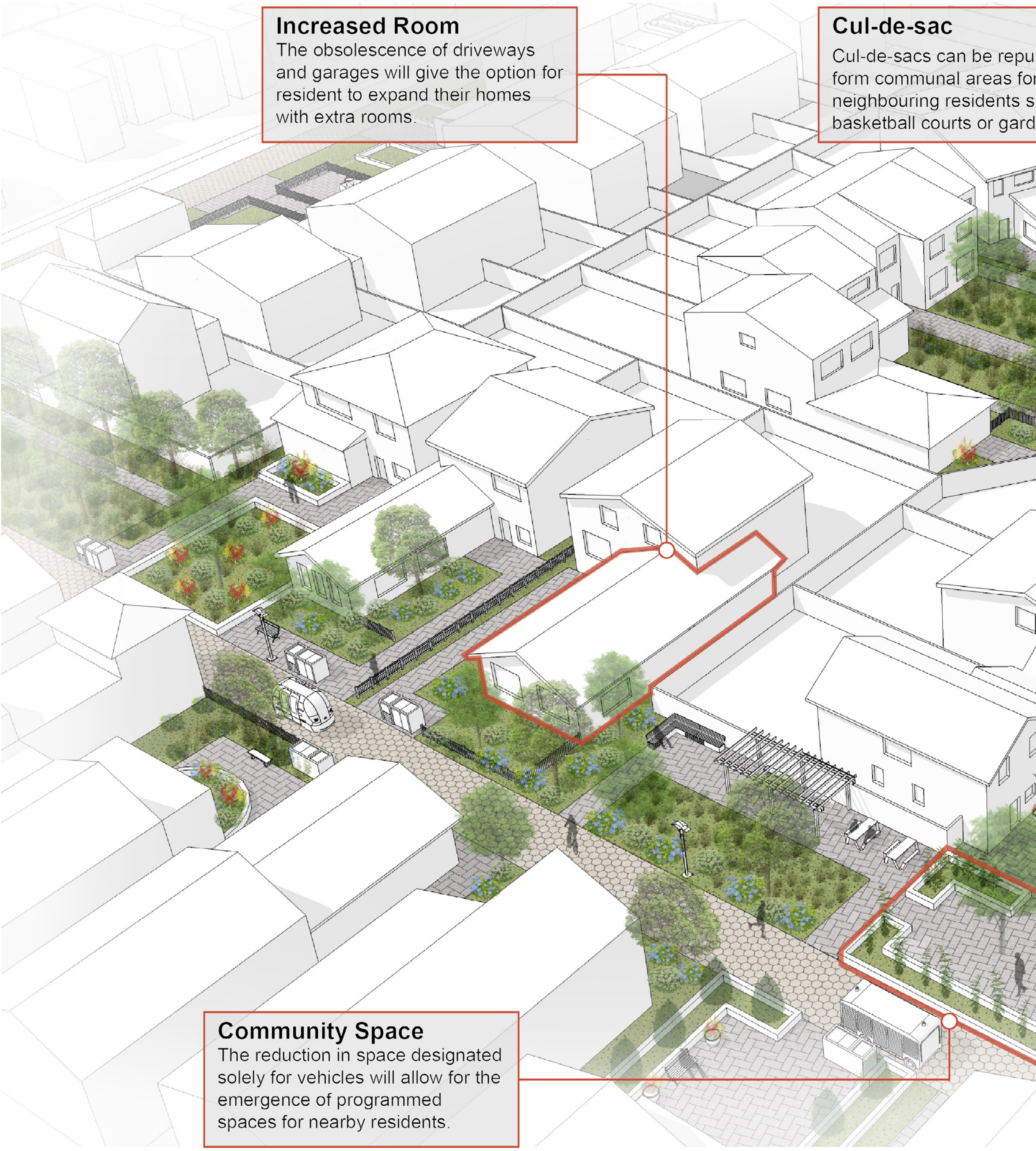
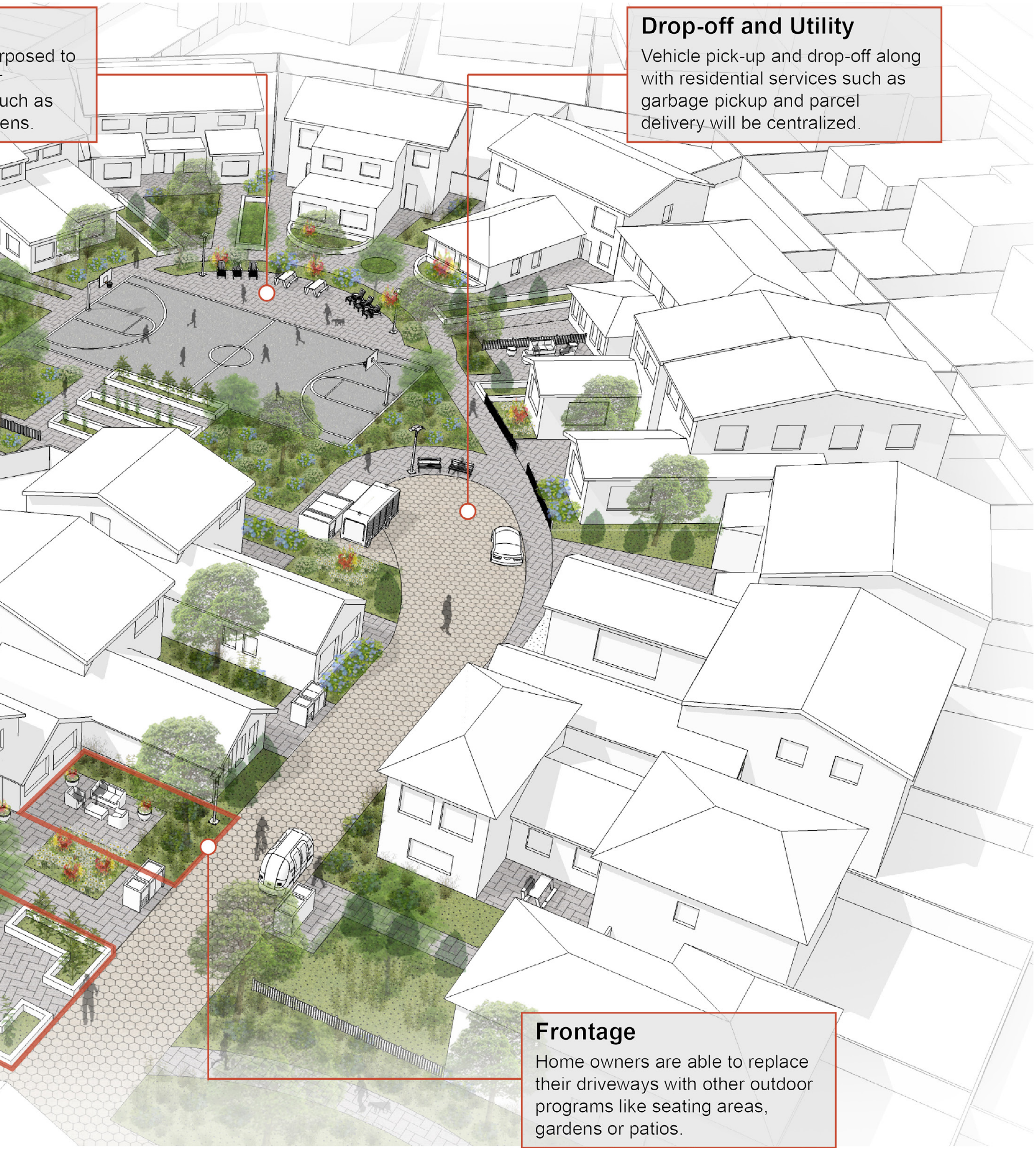
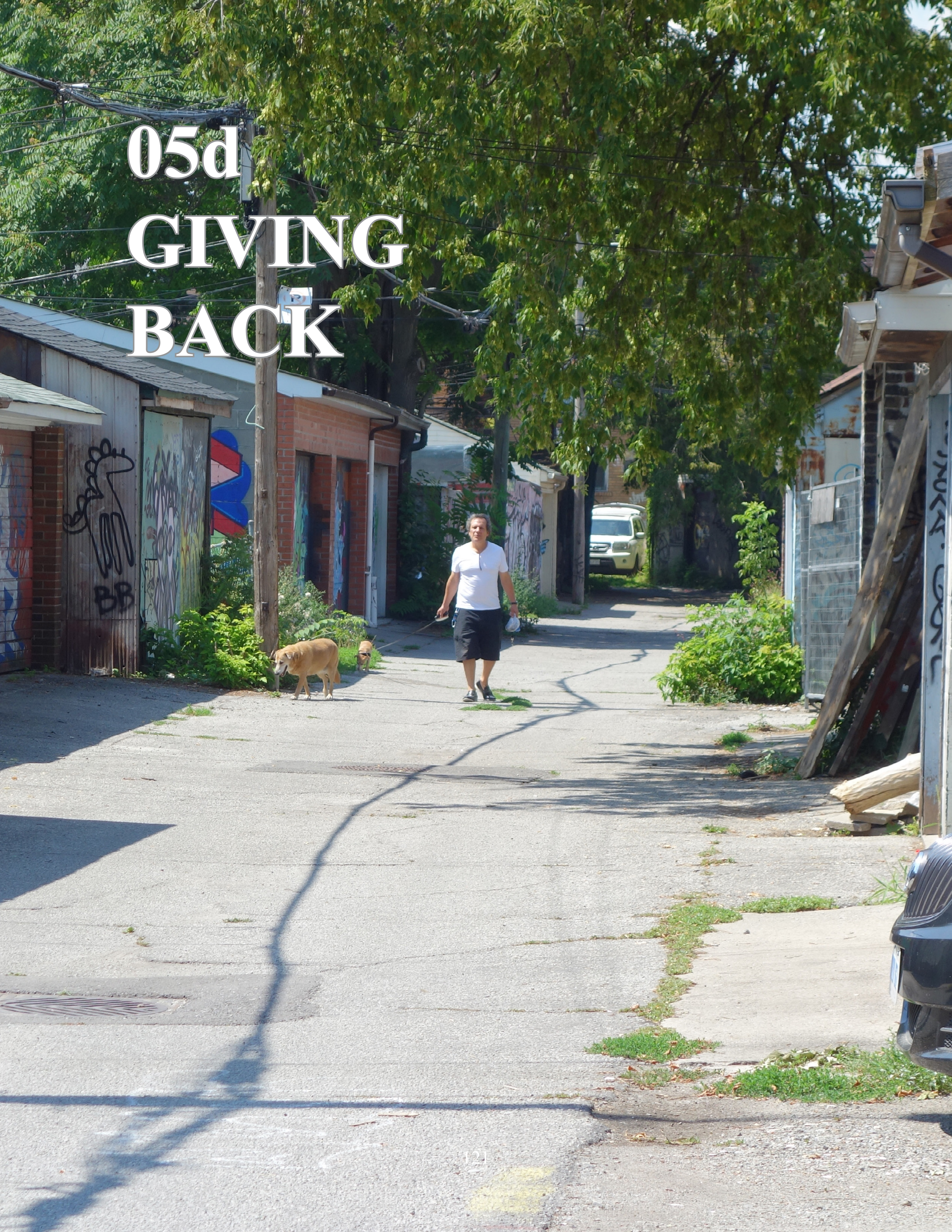


Figure 5.59 - Potential future layout of a suburban neighbourhood enabled by autonomous vehicles



rposed to
uch as
ens.
Drop-off and Utility
Vehicle pick-up and drop-off along with residential services such as garbage pickup and parcel delivery will be centralized.
Frontage
Home owners are able to replace their driveways with other outdoor programs like seating areas, gardens or patios.

05d GIVING BACK



05d
Giving Back

As the population and city became increasingly addicted to and dependent on automobiles, the network of supportive infrastructure for that addiction also expanded. Large parking lots became commonplace, requirements for parking spaces were written into building codes, gas stations were conveniently placed at the intersection of arterial roads, and streets were lined with extra space for parking. Space for parking was so critical that it was not unusual to see parking lots cover more of the lot than the buildings they serve. The oppressive spatial requirements of automotive infrastructure have taken its toll on the limited amount of space available within cities. Street parking lining the sides of commercial shopping streets squeeze the width of sidewalks, barely allowing enough space for pedestrian to walk through. Public and private parking lots are everywhere within the city, taking up valuable space that could otherwise help the shortage of housing and public space in the city. The introduction of autonomous vehicles creates opportunities for cities to re-examine the heavy investment in automotive infrastructure and perhaps rebalance the function of space within the city.

As the mobility of urban populations begin to shift towards an autonomous future of Mobility as a Service, the automotive infrastructure built within cities will become increasingly obsolete. Public parking lots will no longer be needed as more and more people get dropped off from an autonomous cab. Gas stations will no longer need to be conveniently placed next to arterial roads as the number of drivers diminish. What then should this newfound space be transformed into? Personal garages could be transformed into additional housing units as more people transition to living in cities in the future. Parks and green space could replace the open swathes of asphalt previously dedicated to public parking lots. Parking garages could be renovated into offices or apartments as the number of drivers and thus parking needs fall off. It will be up to architects, urban planners and city planners to create designs that leverage these new opportunities to shape a city balanced for everyone.
should this newfound space be transformed into? Garages could be transformed into additional housing units as more people move to living in cities in the future. Parks and green space could replace the open swathes of asphalt previously dedicated to parking. Parking garages could be renovated into offices or apartments as the number of drivers and thus parking needs fall off. It will be up to architects, urban planners and city planners to leverage these new opportunities to form a city balanced for every one of its users.

Figure 5.60 - (previous page) A man walking his dog down a laneway

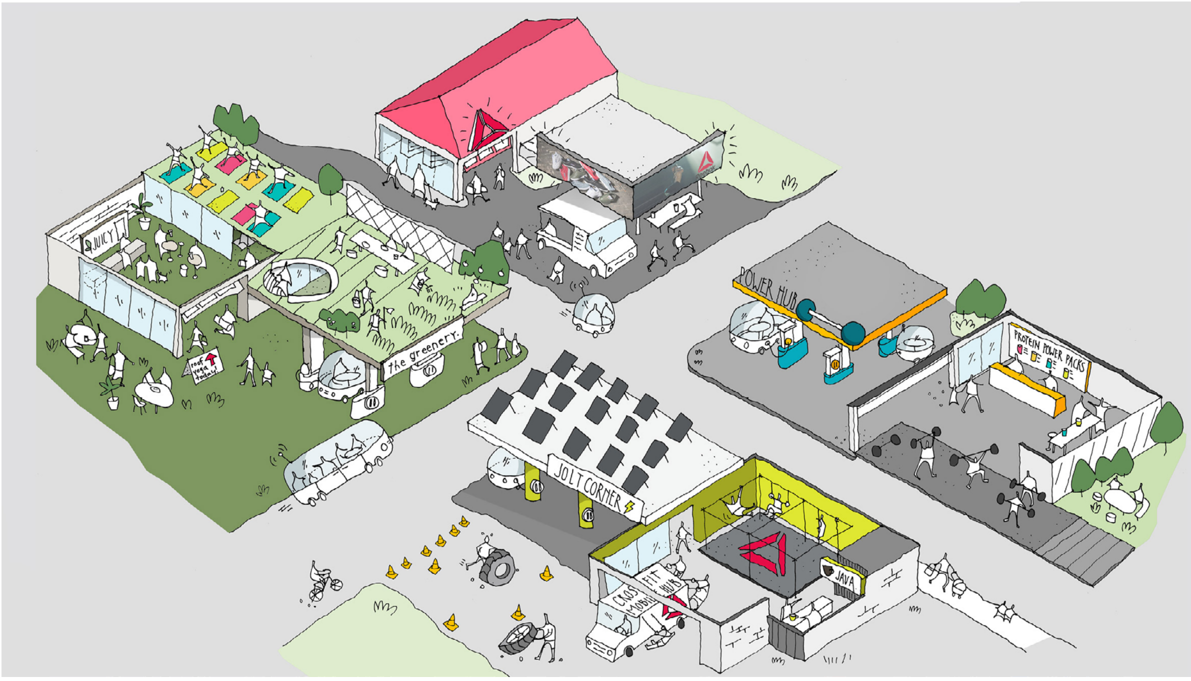


Figure 5.61 - Gensler and Reebok reimagine gas stations

Figure 5.62 - Rendering of a repurposing of a parking garage by Kinder Baumgardner

Figure 5.63 - Green P parking lot

Figure 5.64 - Gas station

Figure 5.65 - On-street parking along a residential street

Figure 5.66 - Crowded public parking lot along Spadina Ave

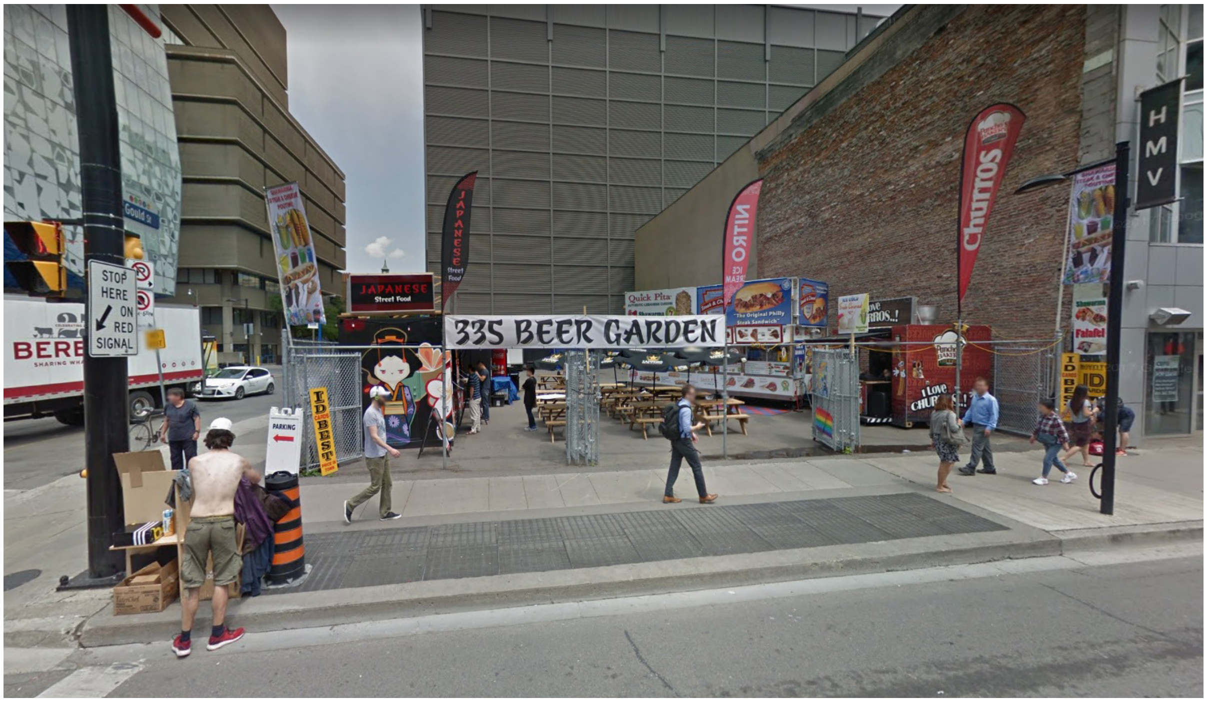


Figure 5.67 - Food carts and stalls occupy an empty parking lot along Yonge Street

Figure 5.68 - Modular green park by BRENS and O2 Planning + Design for King Street Pilot Project

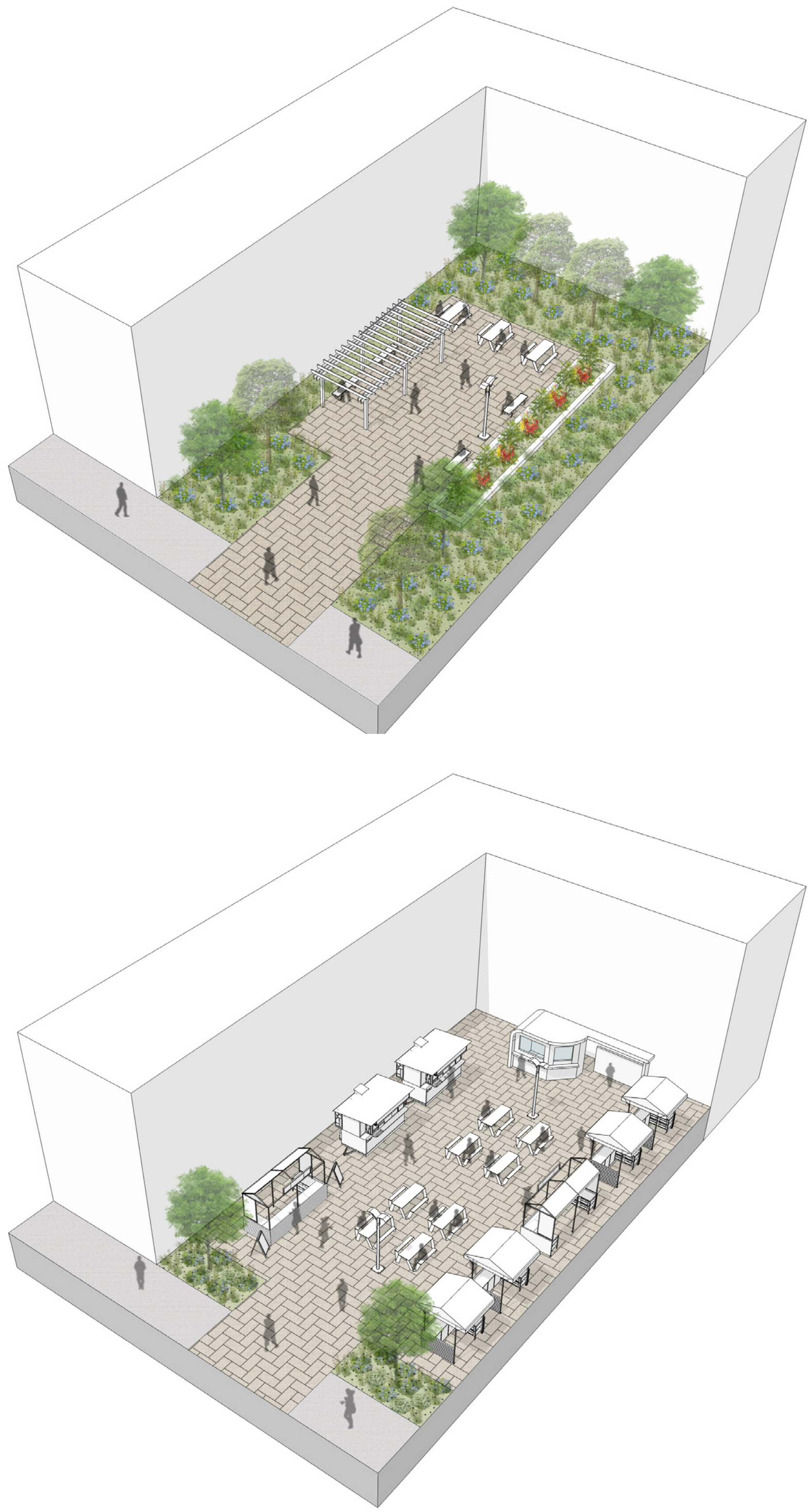


Figure 5.69 - A parking lot repurposed as a green space or a farmer's market

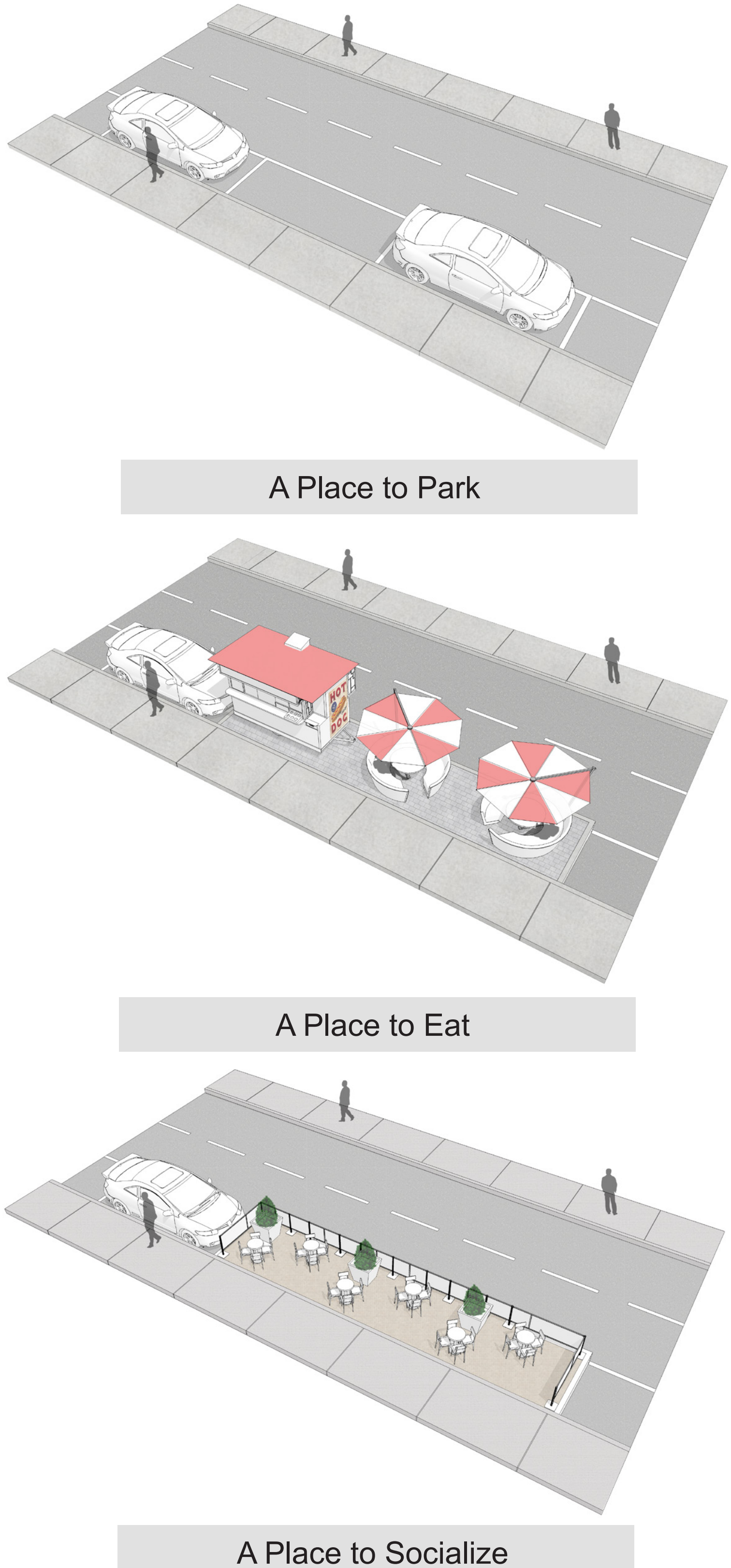
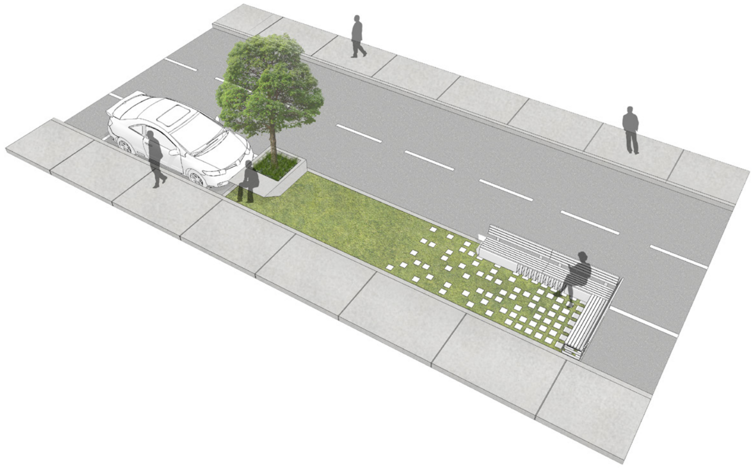
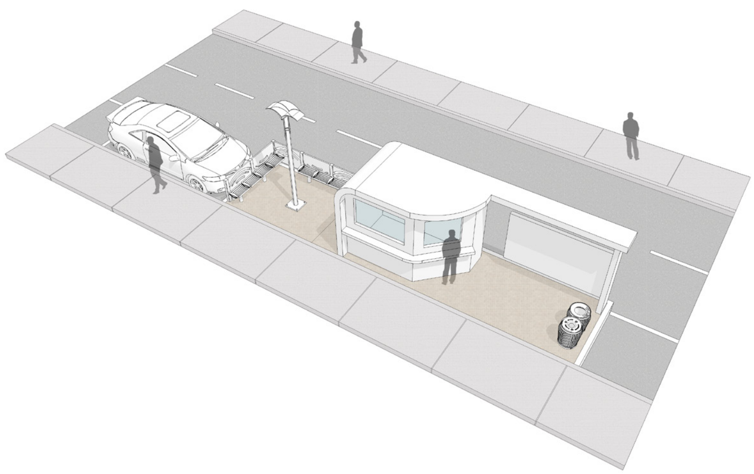


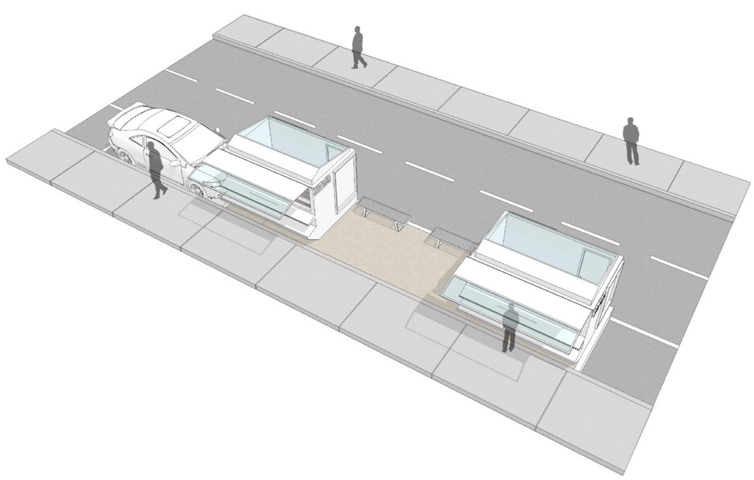
Figure 5.70 - Curbside parking repurposed into various public spaces



A Place to Take a Break



A Place to Gather



A Place to Shop

Kensington-Chinatown

The neighbourhood of Kensington-Chinatown is a bustling section of the city, bordering the central downtown core of Toronto and home to a diverse set of residents. Its population and dynamics are heavily influenced by its adjacency to many of Toronto's most iconic neighbourhoods, Chinatown, Kensington Market, Harbord Village and the University of Toronto. The density of the neighbourhoods allows for most residents to eschew the car, with nearly half of residents preferring to walk or cycle. The proximity of multiple transit lines and lack of space to park a vehicle means that nearly half of residents don't even own a car. Yet these residential laneway neighbourhoods are one of the flashpoints when examining the war between the car and the city. The high density and lack of space on the road cause automobiles to push outside their traditional boundaries, parking over sidewalks or intruding into bike lanes. Laneways, existing solely to facilitate access to detached rear garages, are often neglected, unpleasant and frequently unsafe places to be within the city. The spatial impacts of autonomous vehicles present opportunities to not only soothe many of the current existing frictions but to also give back to the communities that live in those neighbourhoods.

Laneway neighbourhoods, as opposed to suburban neighbourhoods, are much more receptive to the idea of shared public amenities amongst the local community. The obsolescence of automotive structure in these neighbourhoods will allow for the expansion of both the number of residences and public space for the neighbourhood. Laneway garages could be rebuilt into additional housing units to supply Toronto's demand for low cost housing or rebuilt into shared communal amenity spaces such as play space spaces or green seating areas. AVs will provide the chance to reinvigorate laneway neighbourhoods currently restricted by the burdens of automotive infrastructure.

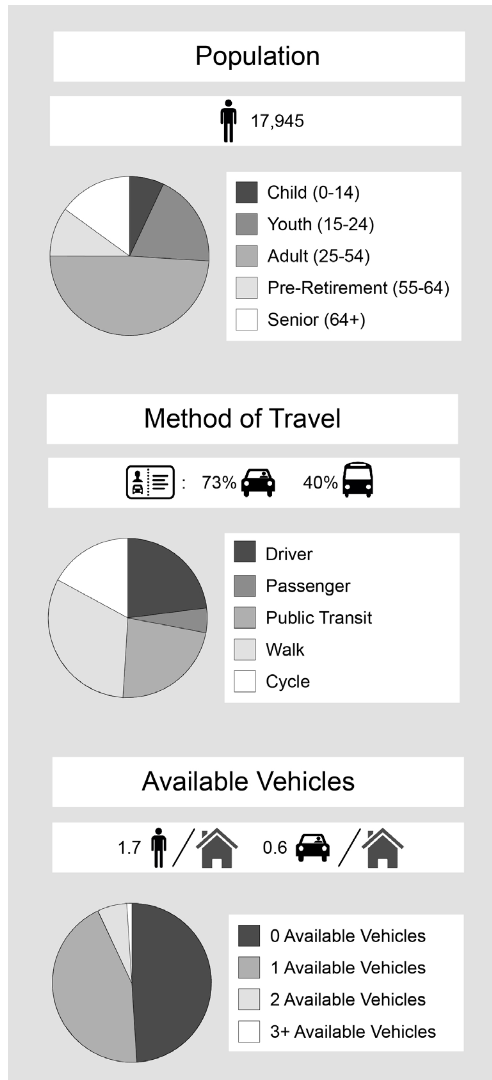


Figure 5.71 - Population statistics of Kensington-Chinatown taken from the Tomorrow Transportation Surey

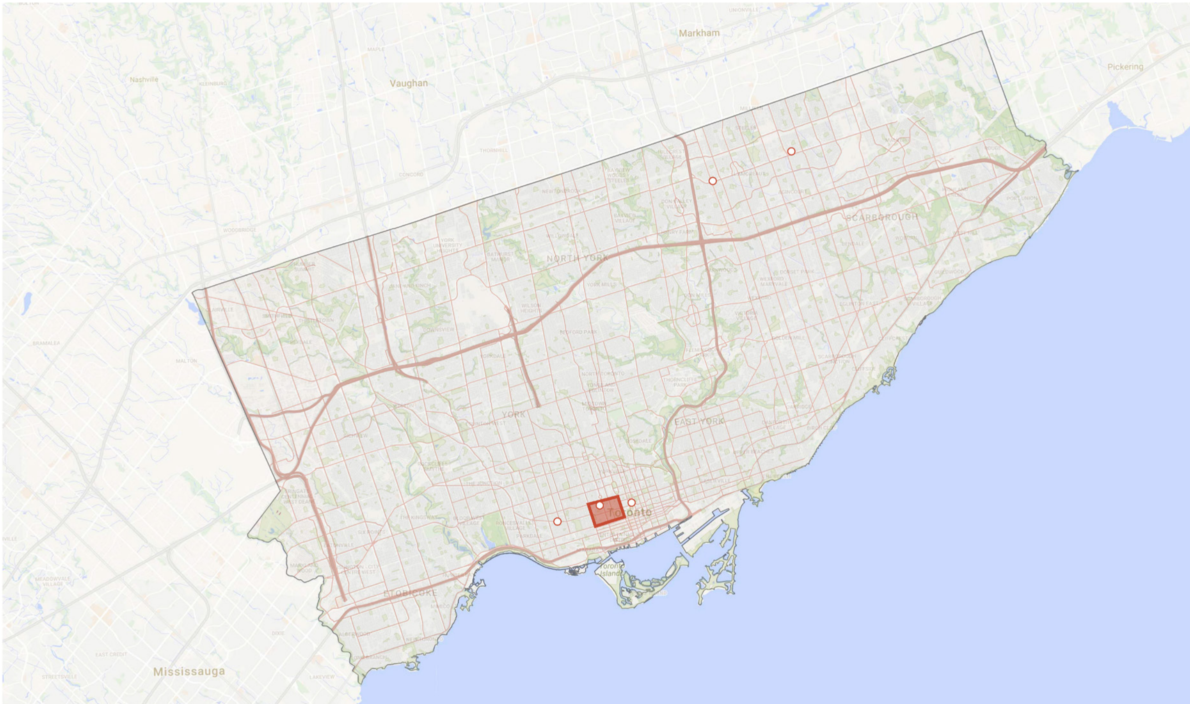


Figure 5.72 - Location of Kensington-Chinatown in the City of Toronto

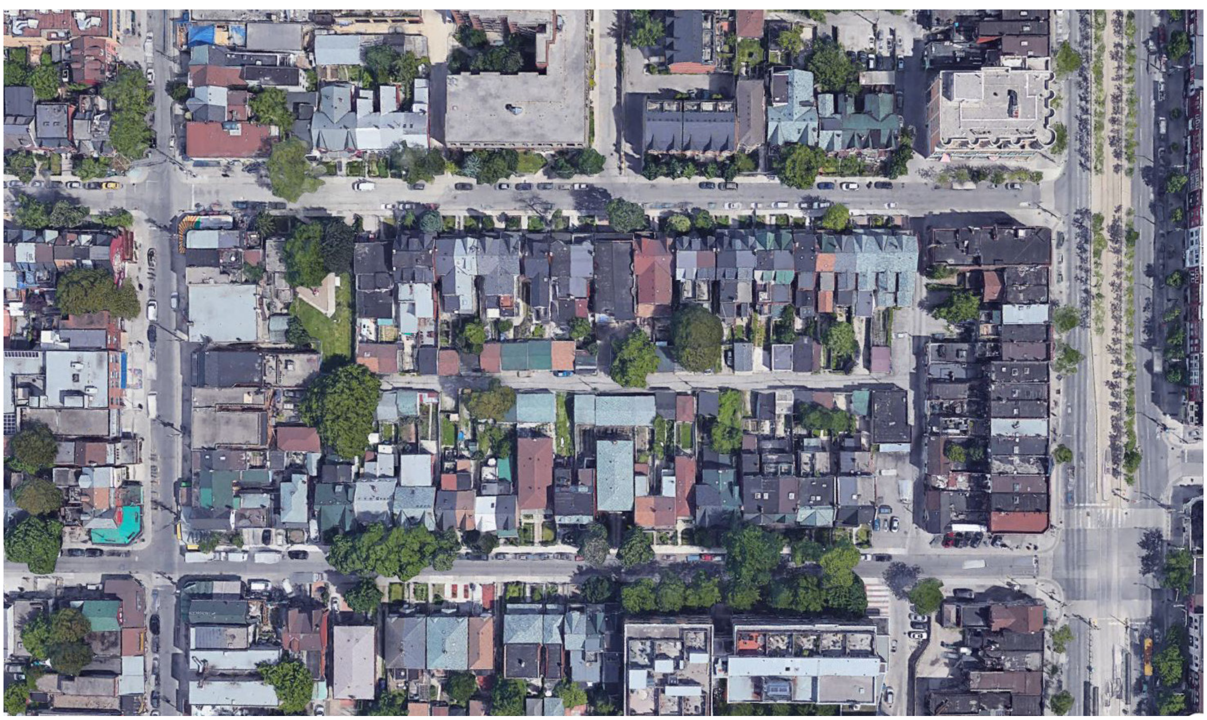


Figure 5.73 - Aerial view of the laneway neighbourhood

Figure 5.74 - Housing units along Oxford Street

Figure 5.75 - A resident pushes a cart down the middle of the street while multiple cars are parked on the sidewalk

Figure 5.76 - A man walks his dog down a graffiti covered laneway

Figure 5.77 - A crowded public parking lot covered in graffiti tags

Figure 5.78 - Kids play ball in the rear loading area

Figure 5.79 - The local grocer takes over the sidewalk to unload the day’s produce

Figure 5.80 - A basketball net is attached to a laneway garage indicating the laneway is used for play

Figure 5.81 - A cyclist and pedestrian have to detour around a Canada Post van parked on the sidewalk

The Opportunities

With the ubiquity of autonomous vehicles, laneway neighbourhoods will have the opportunity to transform into dense, vibrant communities. The transformation of the residential road from a space filled with parked cars to a shared street for play and social activities for the whole neighbourhood will promote active engagement amongst neighbours. Furthermore, the creation of programmed amenity space replacing what were previously empty lots abutting the laneway will allow for communal events such as concerts, pick-up basketball or space for neighbours to share a cup of tea. What was previously an unpleasant, graffiti covered, asphalt laneway could become an animated residential street.

Figure 5.82 - Laneway garage covered in graffiti

Laneway Garages: Laneway garages will transform or be rebuilt into laneway housing units to increase the supply of living units within Toronto.

Public Parking Lots: Public parking lots just off commercial shopping streets can become temporary areas of respite with the addition of seating areas, patio space at the rear of restaurant or green space.

Residential Street: Residential streets no longer become places for vehicles to pass through or to park but rather a shared street amongst the residential neighbourhood for play or social activities.

Rear Residential Parking: The rear of residential units facing the laneway can be transformed into a variety of shared amenity space such as areas of play, performance, gardening or social activity.

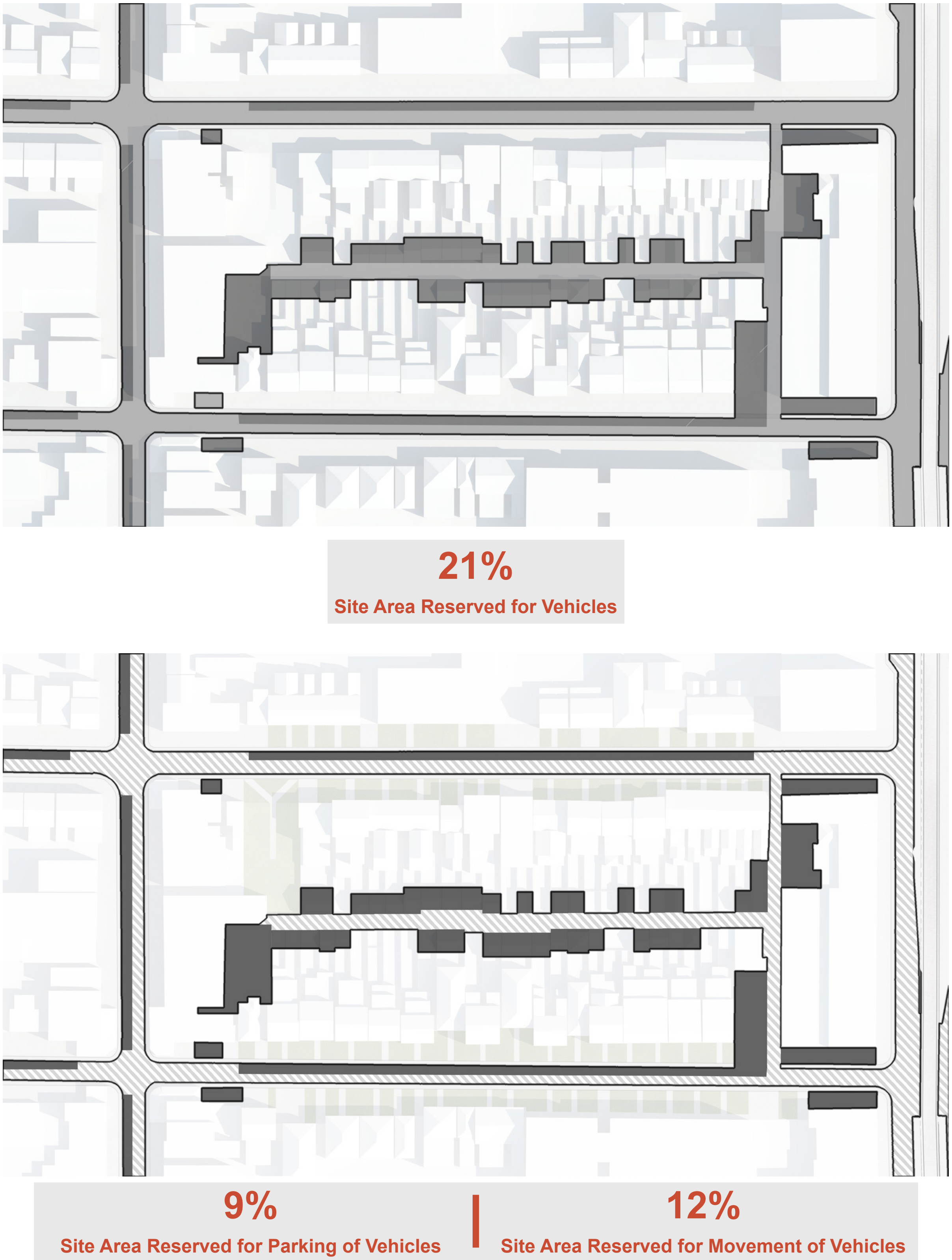


Figure 5.83 - Allocation of space in the laneway neighbourhood

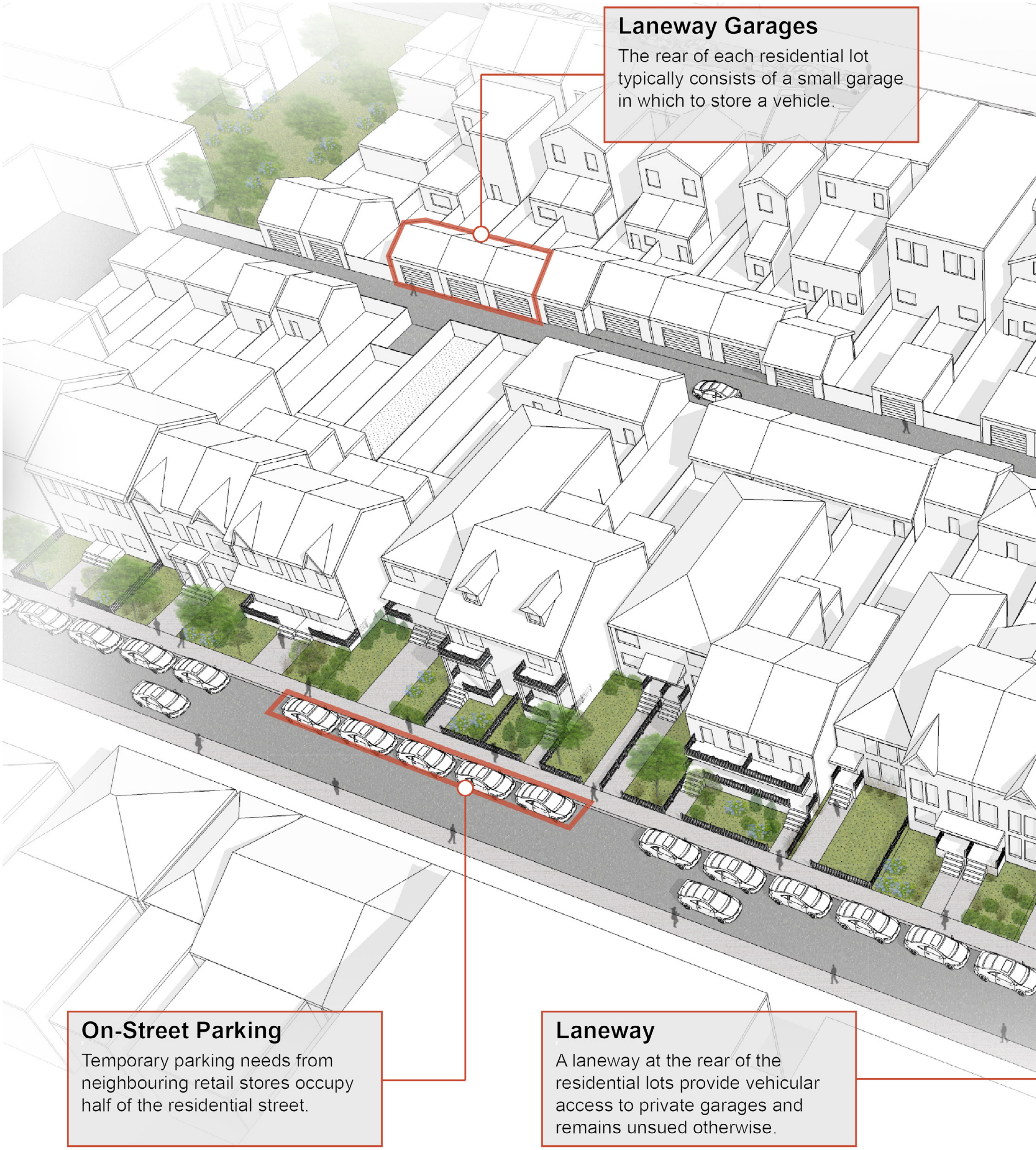


Figure 5.84 - Current layout of the laneway neighbourhood


Public Parking Lots
More long term parking for nearby retail employees or guests of nearby residences are located near the entrance of the street.

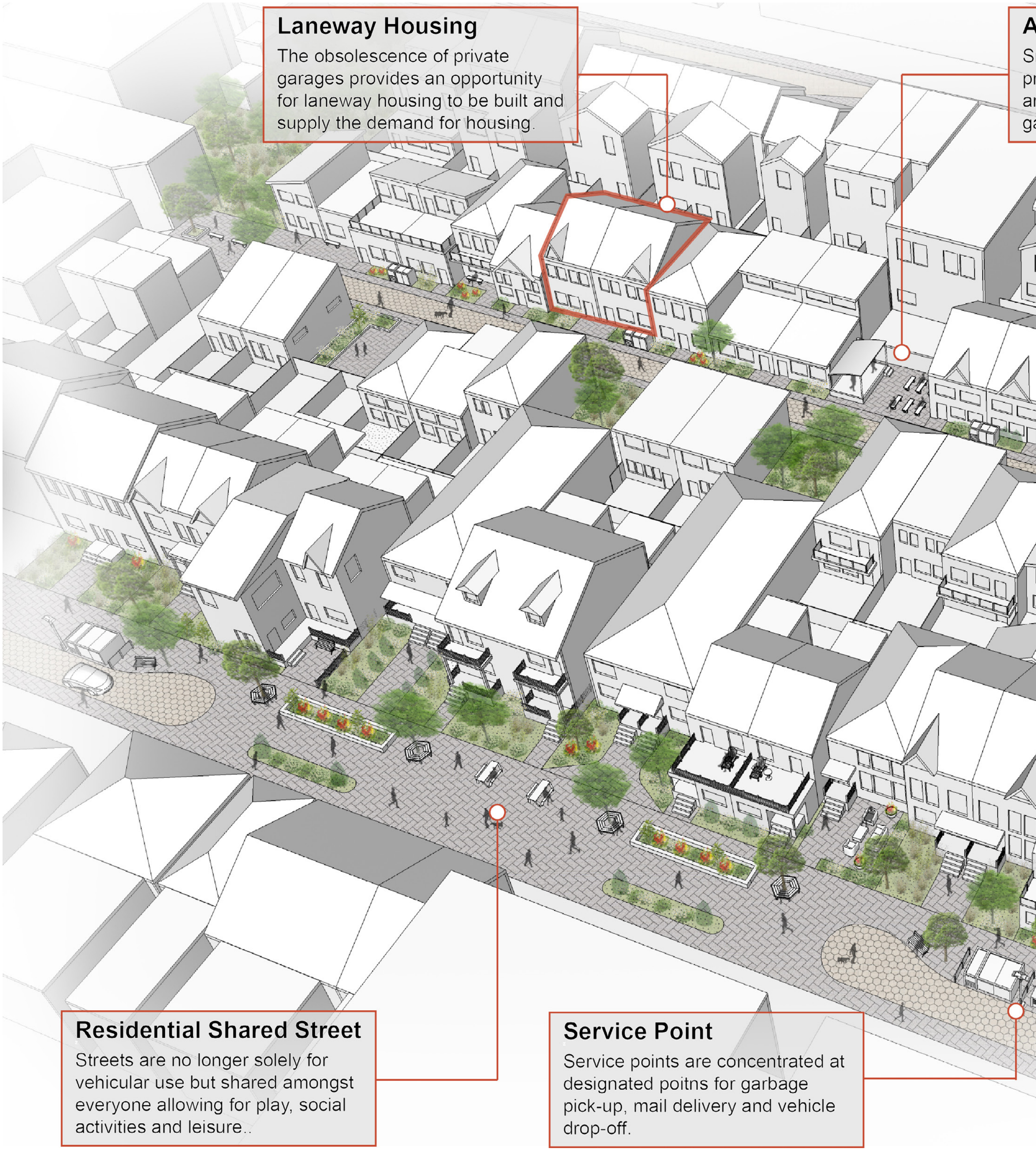
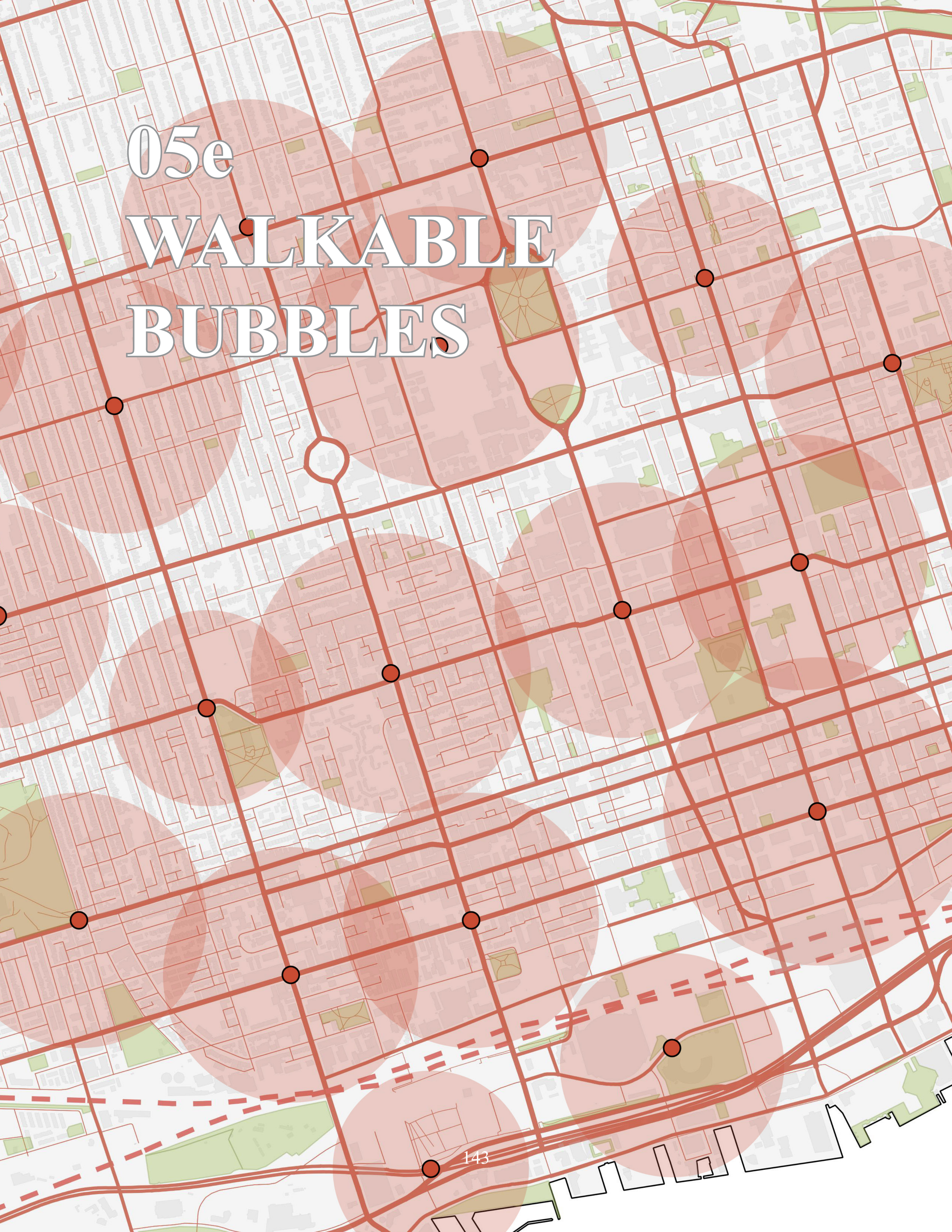


Figure 5.85 - Potential future layout of the laneway neighbourhood


menity Space
mall-scale amenity space
rovides the neighbourhood with
reas for play, performance,
ardening or social activities.
Public Space
Areas previously occupied by
parking lots can be transformed
into temporary public places for
respite off the main retail street.

05e WALKABLE BUBBLES



05e
Walkable Bubbles

The introduction of the automobile completely changed how we spatialize and perceive the city. The speed and power of the automobile, allowing us to travel longer distances within shorter periods of time, shrank the sense of scale within cities. Cities underwent urban sprawl as the convenience of the automobile allowed people to commute from farther away but still stay connected to city centres. This suburban sprawl has caused North American cities to become what Kinder Baumgardner of SWA group describes as "walkable bubbles". In describing this phenomenon he writes:

"I like to think of Houston as a multiverse of little walkable places. In between is all this dark matter of suburban sprawl. So we go from bubble to bubble. On a typical day, you might start off in the suburbs and go Downtown, then walk around, and get some coffee. Onward to the Medical Center, get some tests done, and walk around there. Maybe you go to Rice Village and buy some stuff or meet friends. Then to Uptown and back home. That's how Houston operates, little walkable bubbles in a vast, un-walkable void. Today, navigating the voids is dominated by unpleasant traffic jams, but distances will become less of an obstacle as our autonomous vehicles promise media saturated interiors that smoothly deliver us from walkable bubble to walkable bubble."[2]

Mobility in North American cities has become "a multiverse of walkable bubbles" in which residents drive from one walkable bubble to the next. As technology and mobility develop, the relevance of the journey could eventually be miniscule and the destination all that matters.

A world in which mobility and transport is taken care of at a push of a button also completely changes how we perceive the city. With the current dominance of the car as the method of transport, we understand and spatialize the city as a network of highways and roads. When describing the location of a destination in the city, we name the intersection of the two closest arteries and which streets to get there. How we spatialize the city is tied to how we get there. As autonomous vehicles develop, how people get to destinations remains the same but how people understand the city will change. Instead of roads and highways, which will be taken care of by automation, people will spatialize the city through their destination, the hubs and walkable bubbles. Knowing what streets to drive on or what exit on the highway to take will become things of the past as mobility is automated and condensed to a push of a button.

Figure 5.86 - (previous page) Walkable Bubbles within Toronto

2 *Baumgardner. Beyond Google's Cute Car. 40*

Figure 5.87 - Understanding Toronto through its network of roads

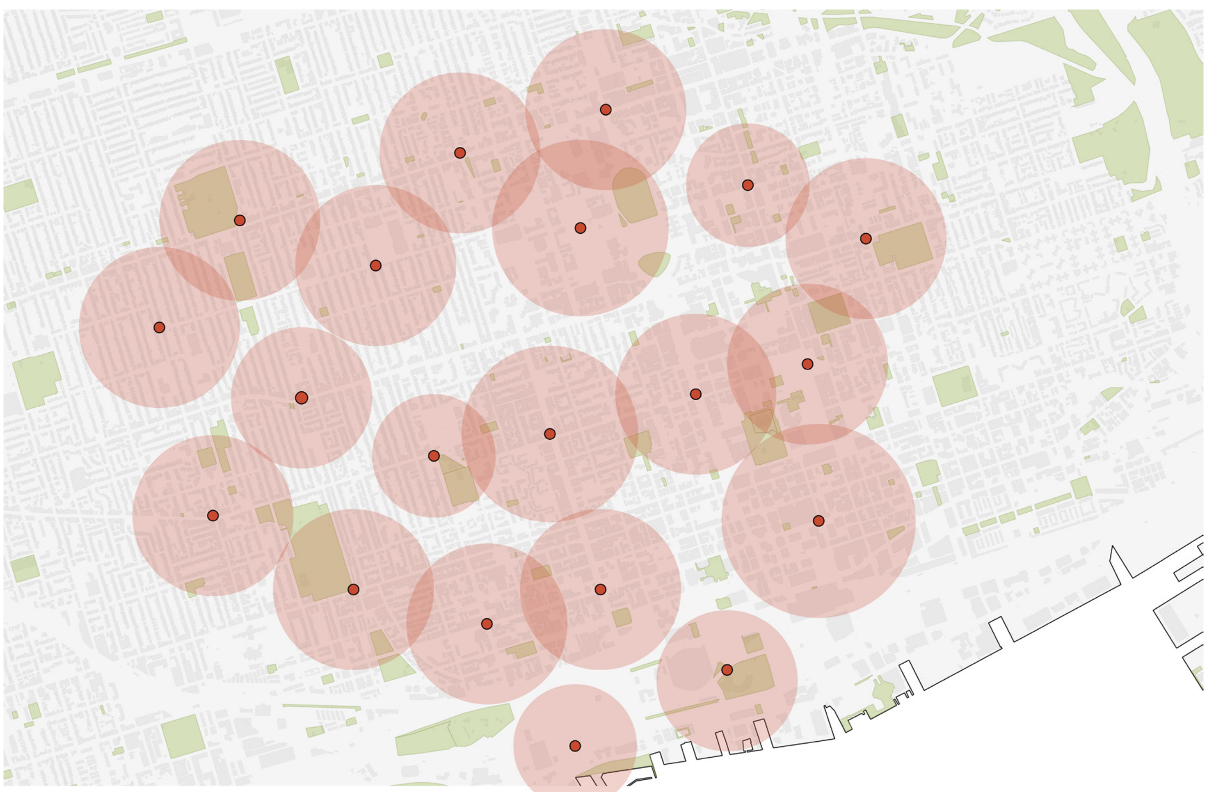


Figure 5.88 - Understanding Toronto as a collection of walkable bubbles

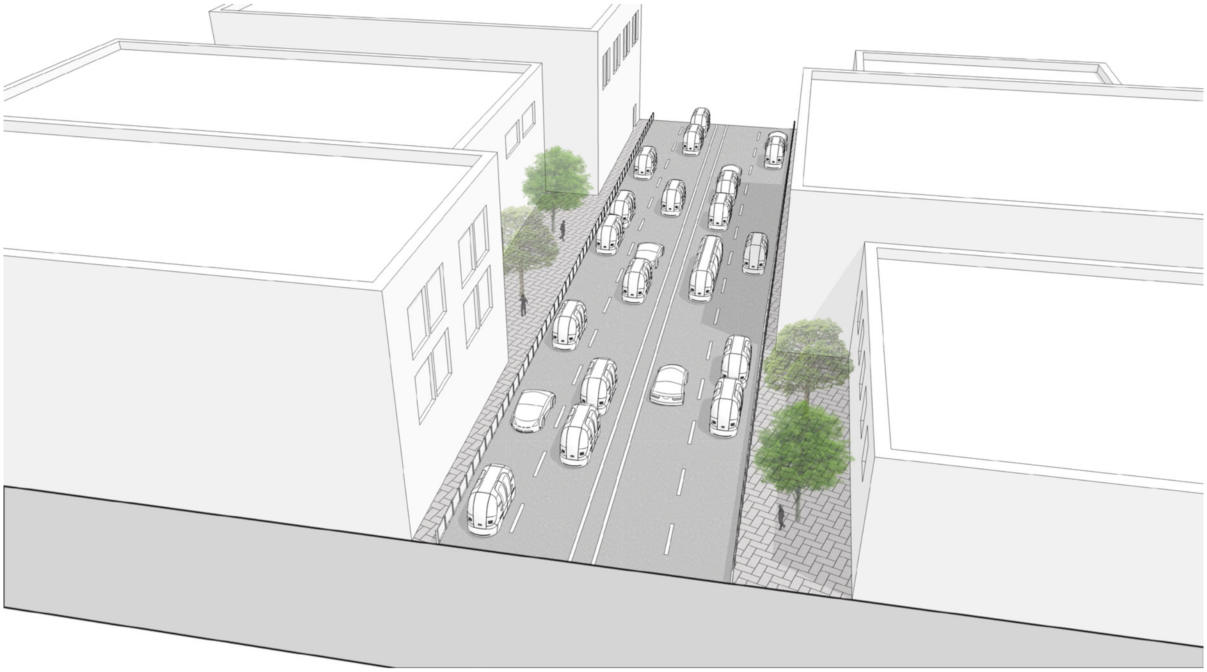


Figure 5.89 - Mobility as a rear alley

Figure 5.90 - Mobility as a parkway

Figure 5.91 - Mobility as a tunnel

Bay Street Corridor

The downtown core of Toronto around City Hall is the heart of the city, filled with tourists exploring the city, office workers enjoying an afterwork drink and locals walking around shopping. Just over 25% of local residents use cars as their preferred method of transport while just under half prefer to walk or cycle. The close proximity of retail stores, services and transit stops greatly reduce the need for the use of a personal vehicle. The site, located at Bay St and Edward St, lies just one block north-west of Yonge and Dundas. While adjacent to the main commercial street of Toronto, Edward Street is predominantly used as an access lane. It provides access to the residential condos off the street, green P Parking and access to loading bays for the retail stores at Atrium on Bay. Rather than lined with restaurants and shops typical of many downtown streets, Edward street is instead lined with on-street parking and drivers looking to cross between Bay St and Yonge.

Downtown streets, such as Edward Street, have the opportunity to become part of a larger pedestrian network as autonomous vehicles become ubiquitous. The continual densification of the downtown core over the next few decades due to an increasing urban population will necessitate further development of retail stores and services to support them. Underground parking garages, which will gradually become obsolete, present an opportunity to expand the pedestrian realm for local downtown residents. The success of underground retail has already been proven through the Toronto wide underground pedestrian PATH system. As more and more underground garages are renovated into areas for retail shops and services, an expansive PATH system will appear in Toronto, forming a whole new pedestrian level throughout the city.

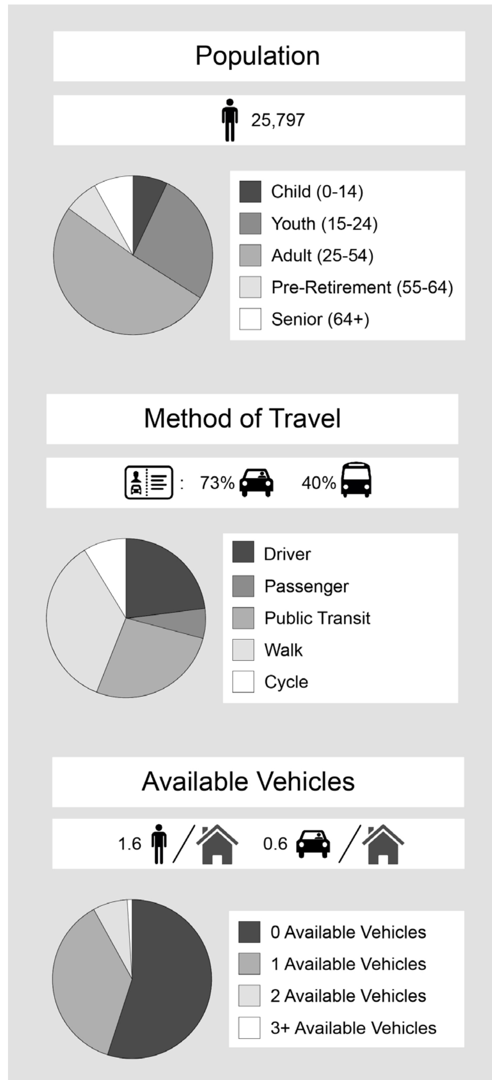


Figure 5.92 - Population statistics of the Bay Street Corridor taken from the Tomorrow Transportation Survey

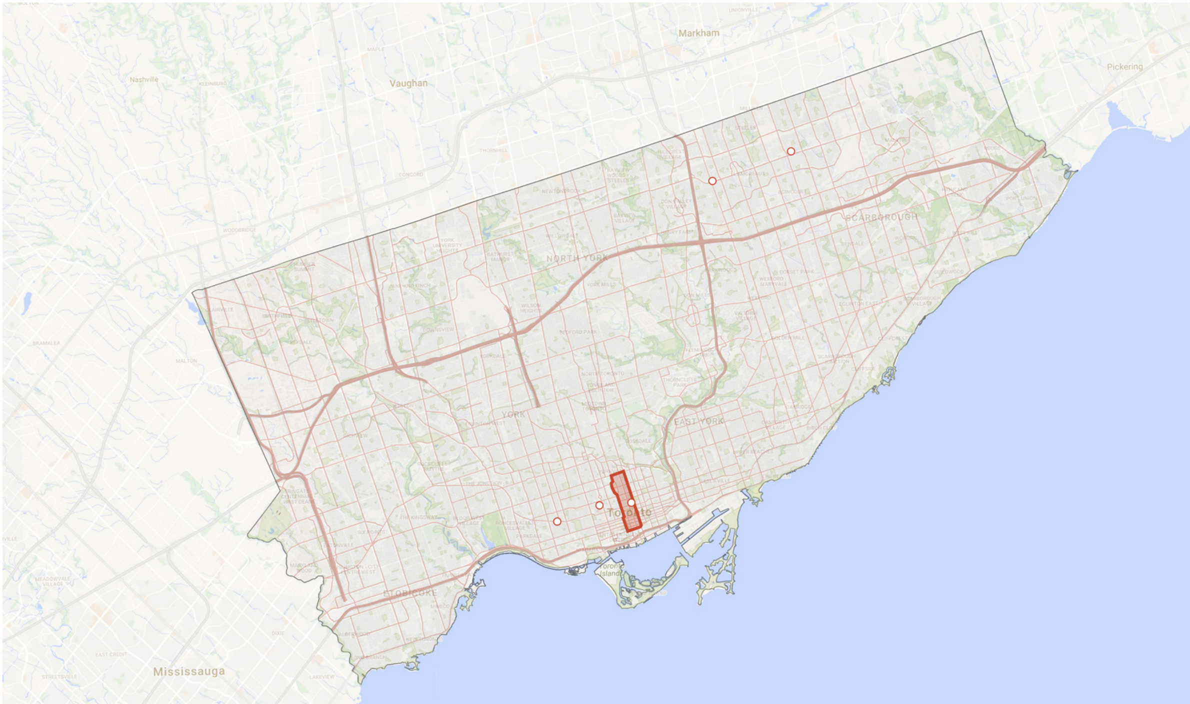


Figure 5.93 - Location of Bay Street Corridor within the City of Toronto

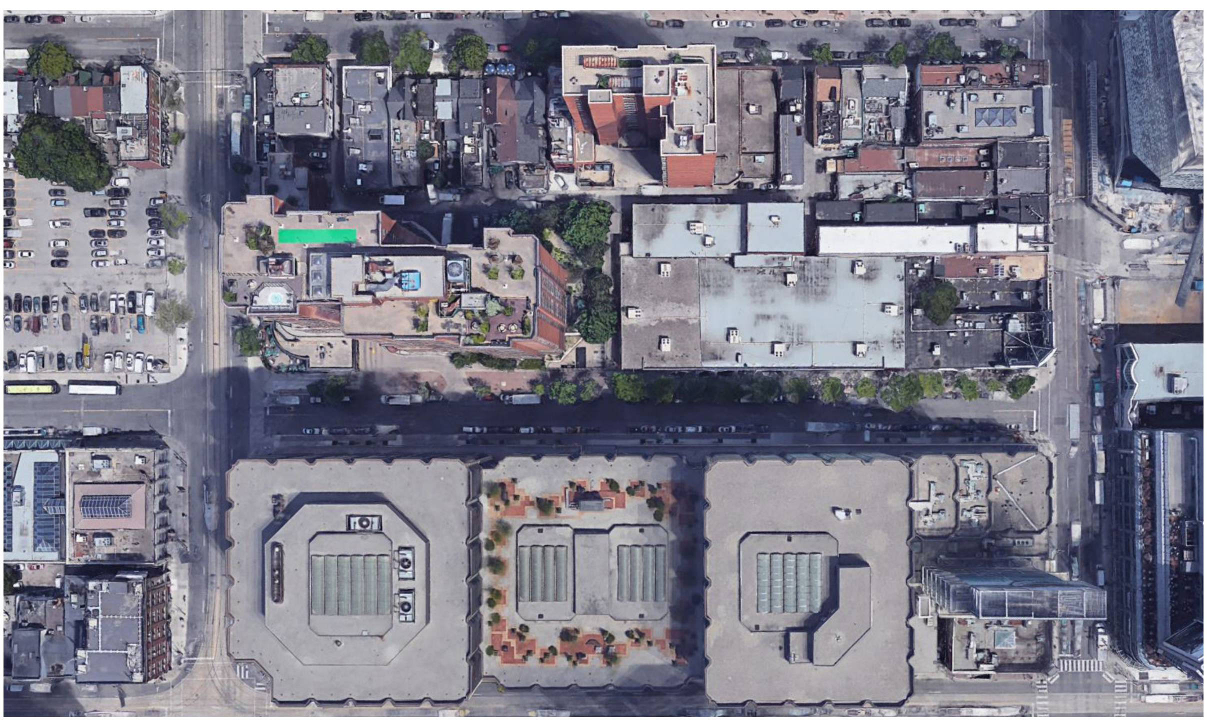


Figure 5.94 - Aerial View of Edward Street between Bay St and Yonge St.

Figure 5.95 - An empty patio at the corner of Bay St and Edward St

Figure 5.96 - Restaurant fronting Edward Street

Figure 5.97 - Unused patio furniture along Edward Street

Figure 5.98 - Locals browsing books on sale

Figure 5.99 - A taxi and delivery truck block Bay Street

Figure 5.100 - Canada post vans line up along Edward St.

Figure 5.101 - Parked cars line both sides of Edward St.

Figure 5.102 - Entrance to the underground public parking lot

The Opportunities

The downtown core of Toronto has been undergoing enormous change within the past decade. Construction cranes are still seen on every city block with numerous condos being built every year. As Toronto continues to densify and its population continues to grow, the network of supporting services, commercial stores and public space will need to expand as well. The centralization of automotive infrastructure along key highways as well as the liberation of access roads and underground parking will allow for a brand new below ground pedestrian level to emerge. A network of high speed roadways will weave itself within the city, ferrying people to and from pre-programmed nodes, from walkable bubble to walkable bubble.

Underground Parking: As the ubiquity of autonomous vehicles render underground parking unnecessary, the unused space could be converted into additional retail stores and connected to the Toronto PATH system.

Downtown Parking Lots: Many of these asphalt lots have already begun to be converted into condo towers and medium density retail. As Toronto continues to grow in size, these lots will be converted into high rise condos or office towers.

Access Streets: What was once a street primarily for on-street parking and a means to get to underground parking, can be transformed into a sunken pedestrian street providing public space and shops for the increased density.

Access Points: Specifically designed drop-off points will be the main way to access and leave the walkable bubbles throughout the city.

Figure 5.103 - Underground parking under Atrium on Bay

Figure 5.104 - Pedestrian entrance to the PATH system at Atrium on Bay

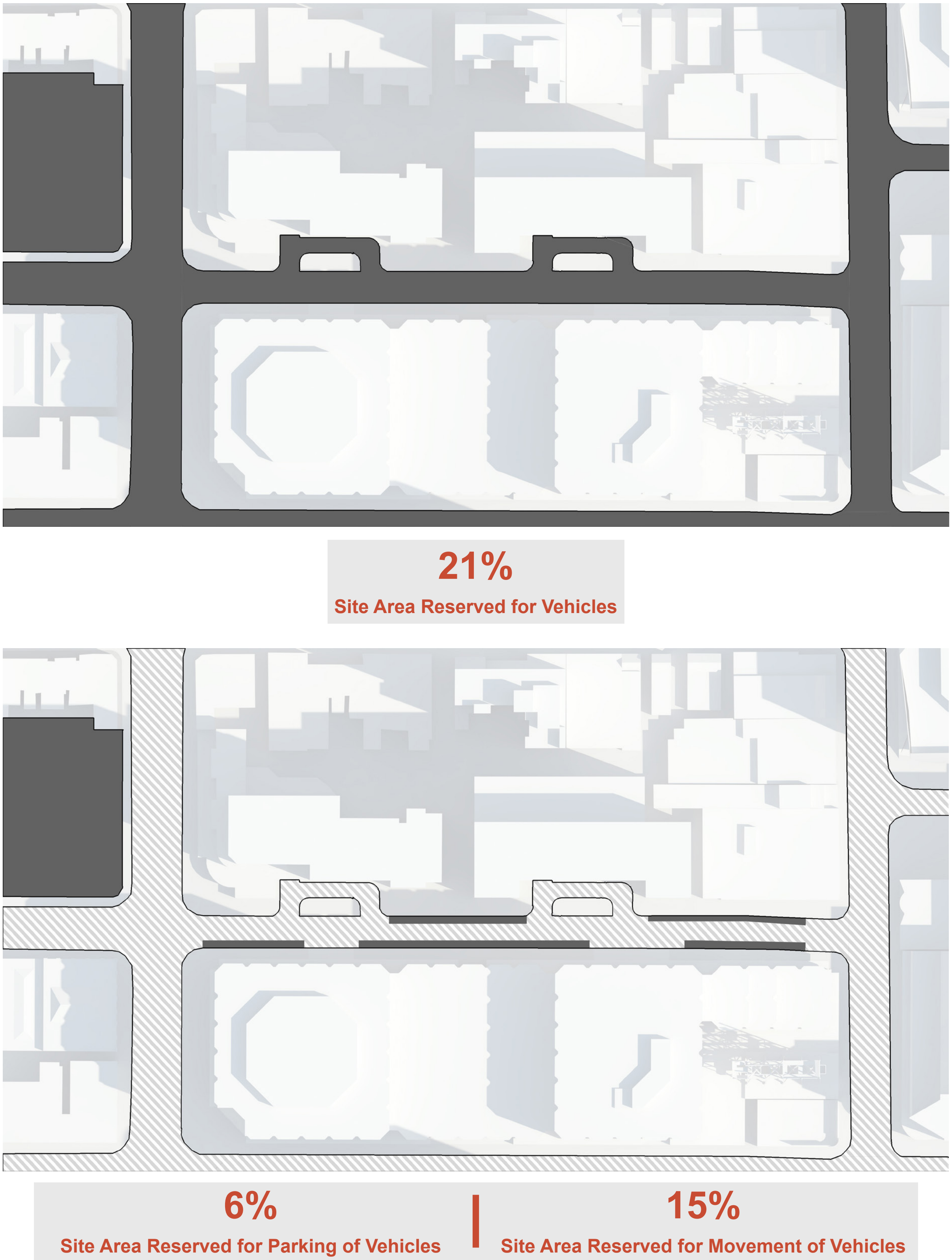


Figure 5.105 - Allocation of space along Edward St.

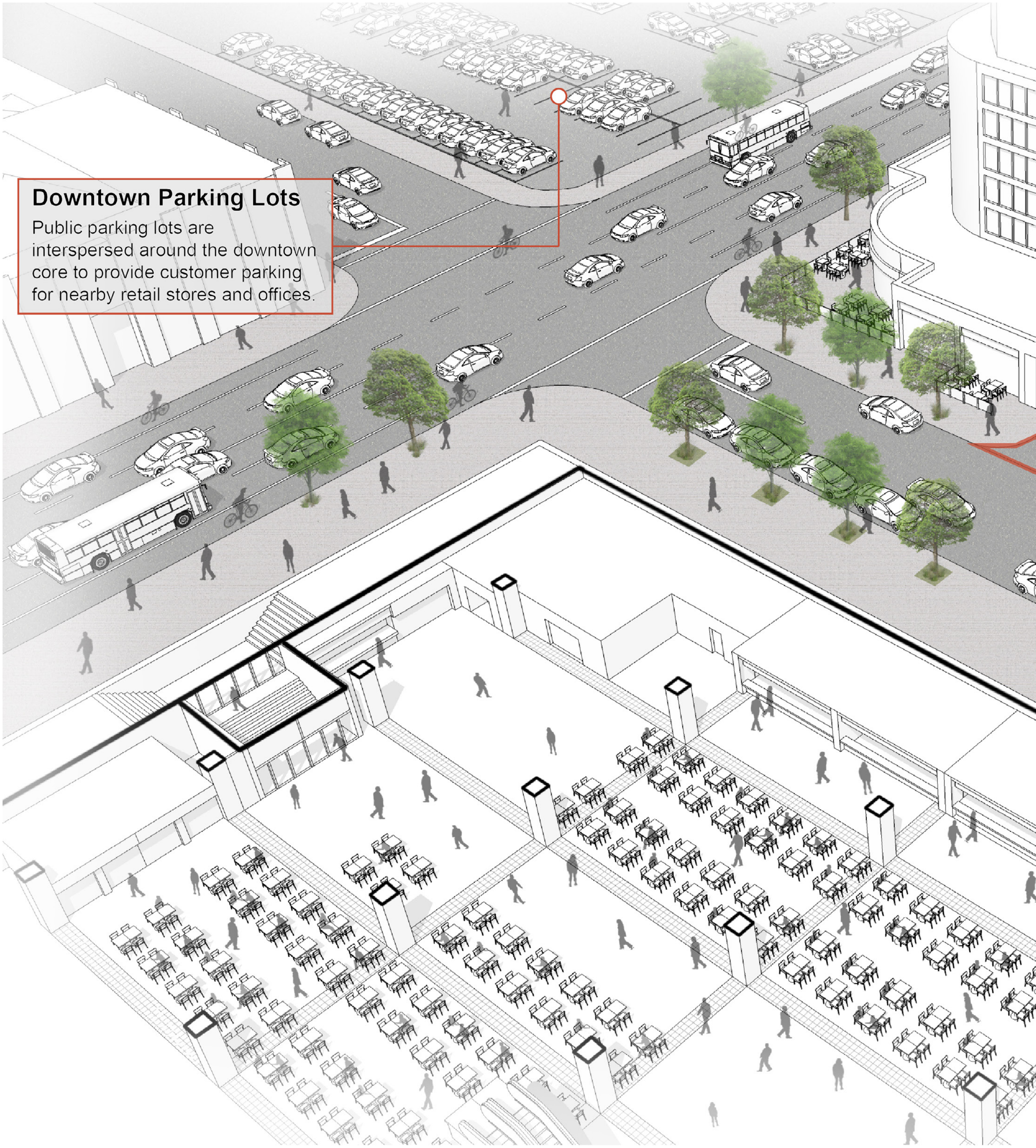
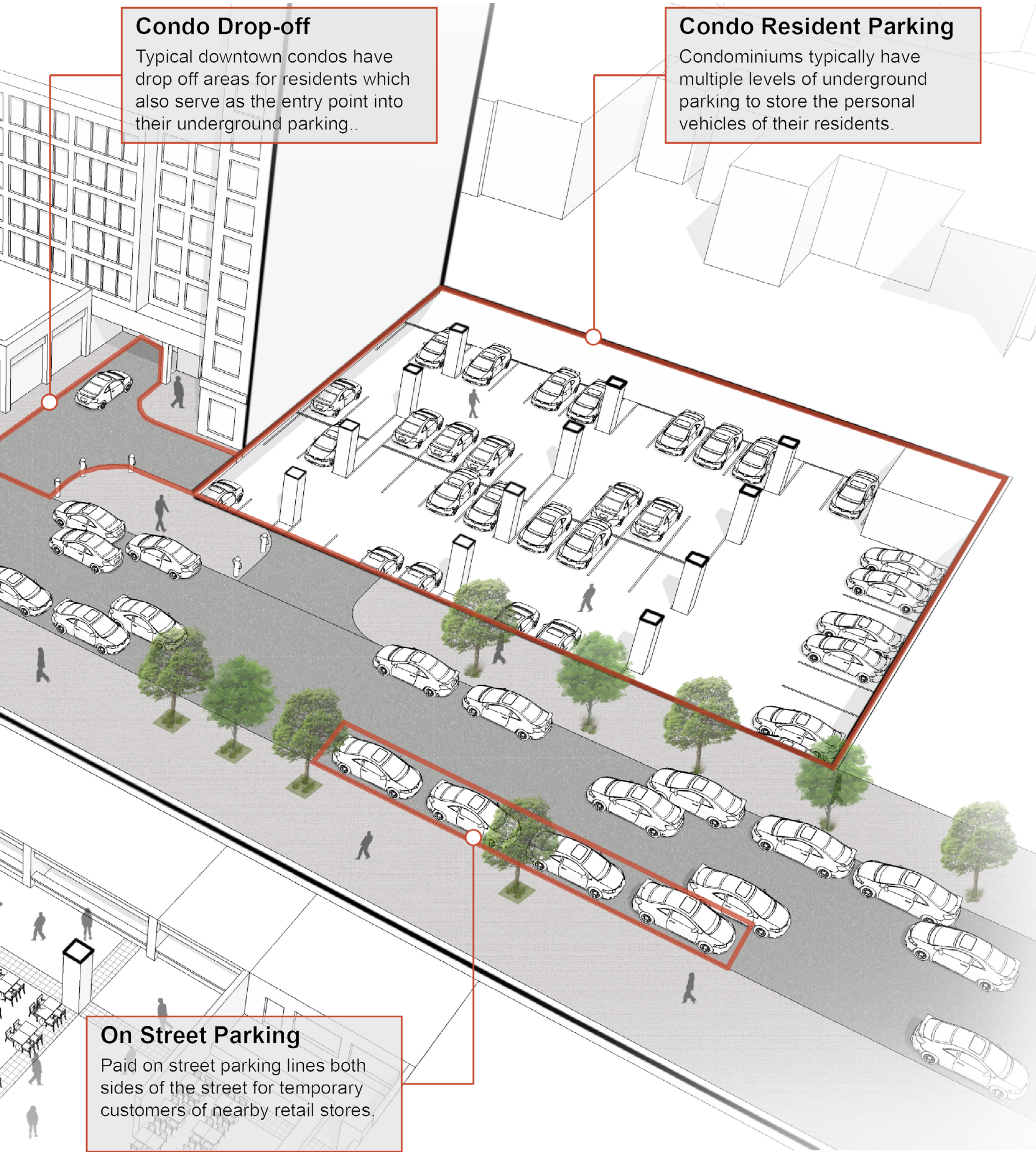


Figure 5.106 - Current layout of intersection of Bay St. and Edward St.


Condo Drop-off
Typical downtown condos have drop off areas for residents which also serve as the entry point into their underground parking..
Condo Resident Parking
Condominiums typically have multiple levels of underground parking to store the personal vehicles of their residents.
On Street Parking
Paid on street parking lines both sides of the street for temporary customers of nearby retail stores.

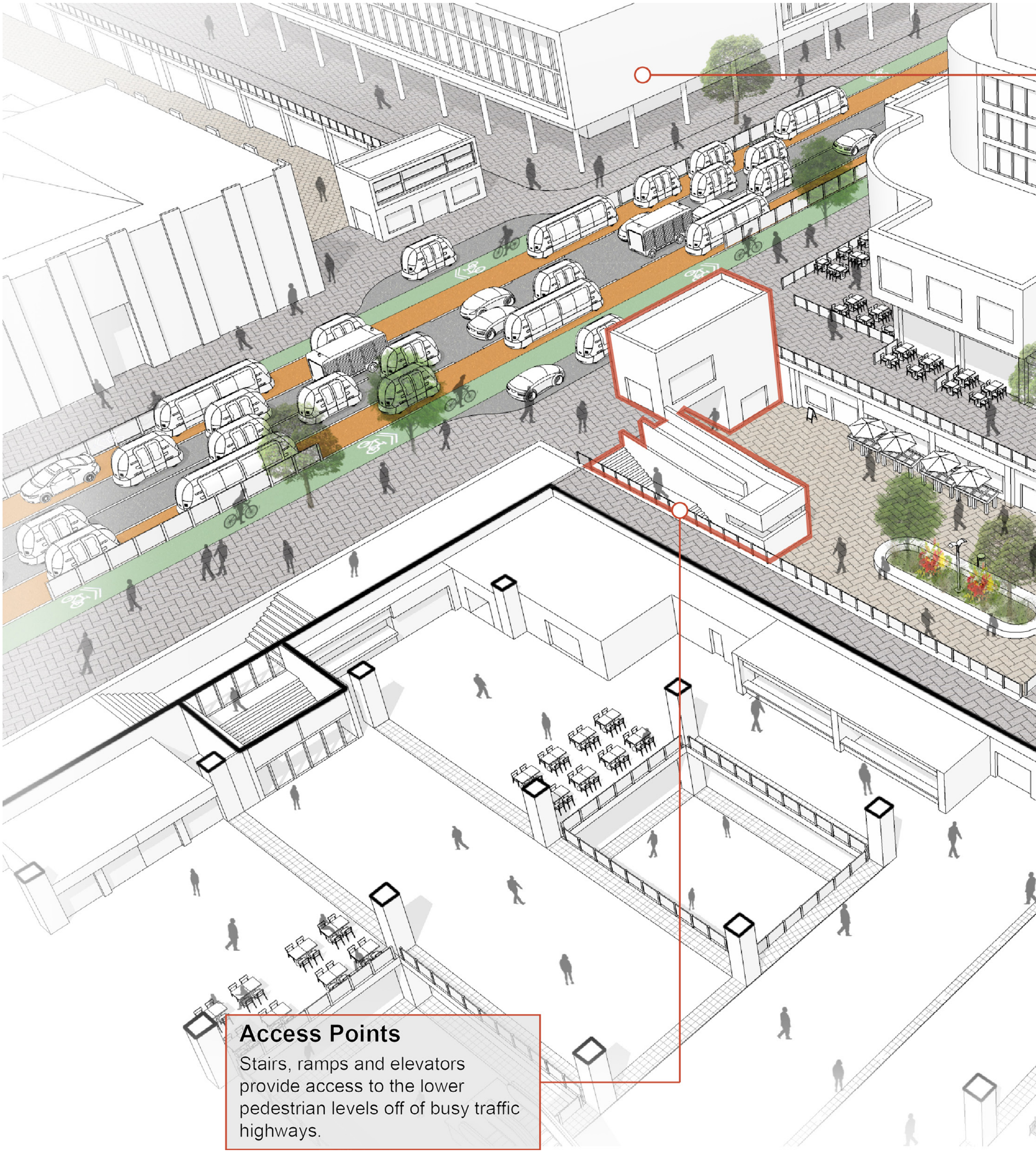
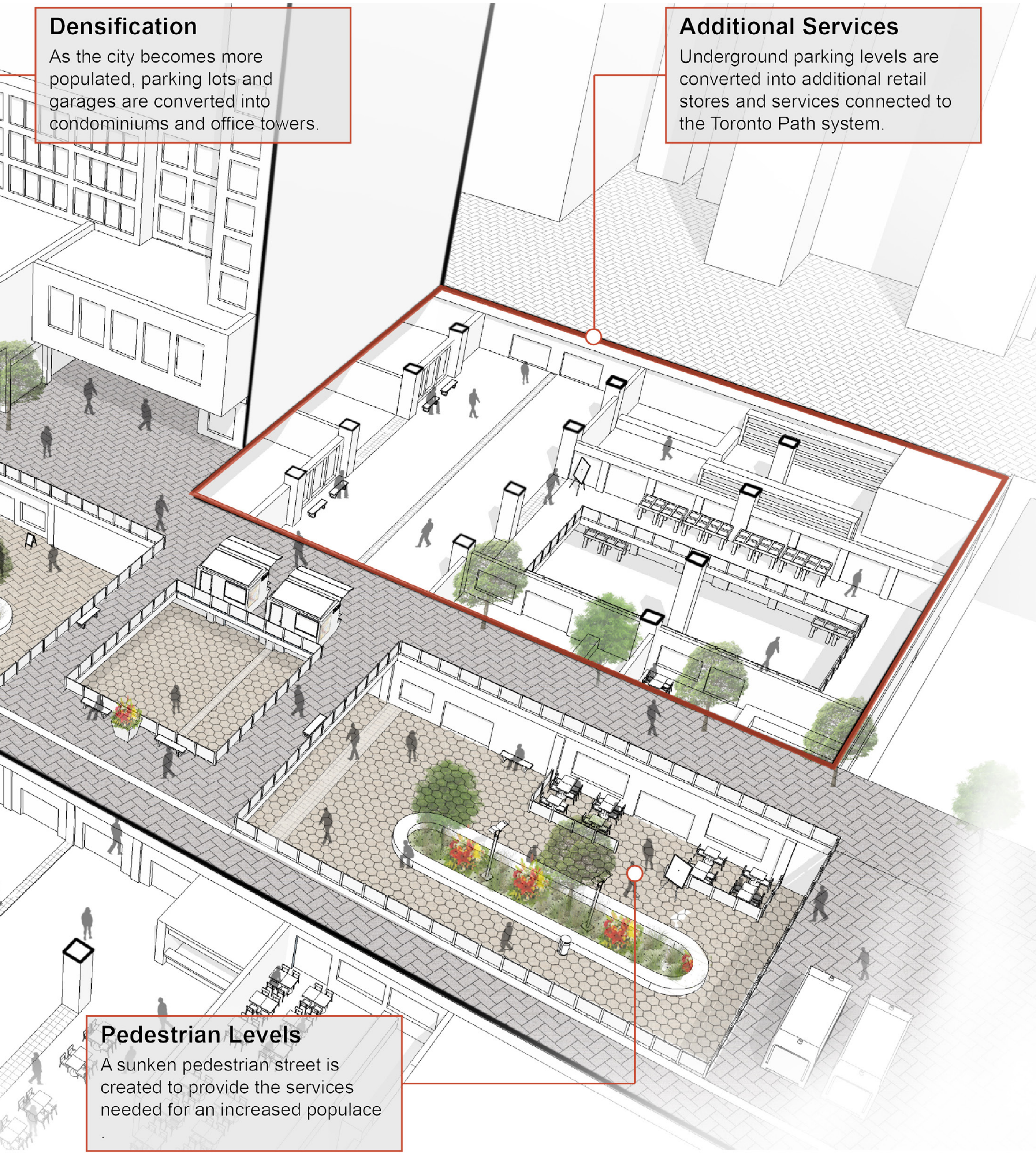


Figure 5.107 - Potential future layout of intersection of Bay St. and Edward St. connected to the PATH system


Densification
As the city becomes more populated, parking lots and garages are converted into condominiums and office towers.
Additional Services
Underground parking levels are converted into additional retail stores and services connected to the Toronto Path system.
Pedestrian Levels
A sunken pedestrian street is created to provide the services needed for an increased populace
.

5.2
Conclusion

The advent of autonomous vehicles will happen sooner than many of us think. To most of the population, it is still a distant thought, something they once read on the news and forgot about the next day. To those who have seen it in action or travelled in one during a pilot project, the technology remains in the realm of science fiction and decades away from use. To the very few policy makers and urban designers who have heard of autonomous vehicles, the technology is regarded as just another iteration of current automobiles on the road. Yet autonomous vehicles have the capacity to and will completely revolutionize urban mobility. The consequences of a shift towards autonomous vehicles will be astronomical, significantly more disruptive than the transition from horse powered mobility to automobiles at the beginning of the 20th century. It will have an impact on nearly every industry in the modern economy and drastically transform how we use the space of our cities. Similar to the advent of automobiles, the implementation of autonomous vehicles has the capability to both create a dystopian or utopian future city.

Urban designers, architects and city officials need to spend the next decade thinking of how best to integrate AVs into our cities. The mistakes of Modernist urban design and its infatuation with enabling the car cannot happen again. Urban designers and planners will once again be faced with decisions on how best to balance the limited space of city streets, roads and city blocks for everyone in the city. No person can accurately predict every consequence of the ubiquity of autonomous vehicles nor design the perfect street that satisfies every user. When designing the city of the future with autonomous vehicles, urban designers will need to adapt, prototype, experiment and be quick on their feet in adjusting the public space of the city to its needs. City designers will be offered a whole new range of tools and opportunities as a result of autonomous technology. There will be opportunities to make city life more affordable. There will be opportunities to make city life more sustainable. There will be opportunities to make city life more accessible, safe and enjoyable. But there will also equally be opportunities to make city life unhealthy, fragmented and segregated. Urban designers and city planners will need to tread carefully as the city is once again set to morph due to a revolution in mobility.

The designs and ideas presented predominantly paint an optimistic, but at times critical, vision of a city enabled by autonomous vehicles. The work focuses on many of the current issues that plague cities, such as unaffordable housing, lack of pedestrian space, cyclist safety and the overbearing requirements of automotive infrastructure. Although appropriate in the present day and in particular Toronto neighbourhoods, these priorities may not necessarily hold true for every city or in the coming decades as AVs grow in popularity. The transformation of laneway housing into additional residential units may over densify residential neighbourhoods or the convenience of autonomous vehicles could end up completely discouraging walking. As such, the renderings and diagrams illustrated should serve as potential pathways of how cities could leverage opportunities generated from autonomous vehicle technology.

What will be interesting to see over the next several decades is how the assumptions the design scenarios are founded on will pan out. Although we can make educated guesses, that autonomous vehicles will require less space to move, to park and people will give up ownership of cars for shared vehicles, the presumptions could potentially go the other way. It is impossible to predict each and every repercussion of the ubiquity of autonomous vehicles. As urban designers and architects, we can only hope that the designs we put forth make the city more affordable, accessible, sustainable and enjoyable for years to come. One thing is for sure though, the cities of 2050 will be beyond our wildest imagination and be completely unrecognizable from the cities of today.

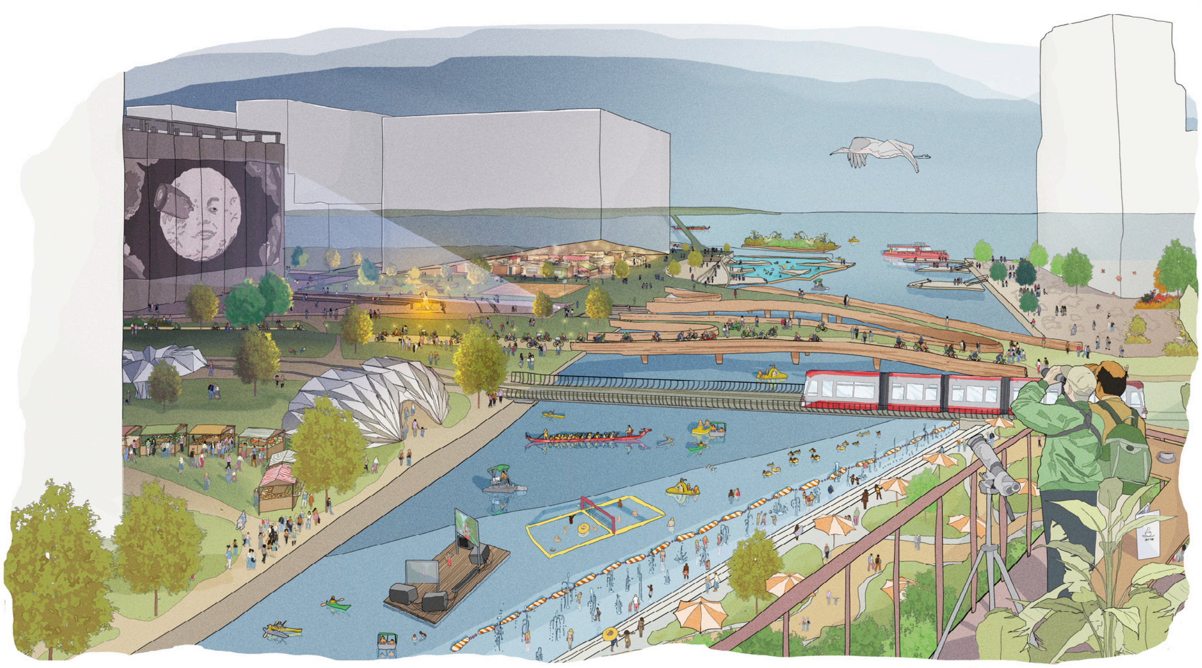


Figure 5.108 - Rendering of new Quayside Neighbourhood by Sidewalk Labs

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