Travel behavior and the future of transportation systems: From the COVID era to the technology era

TECHNION
Israel Institute of Technology

Yoram Shiftan

Transportation Research Institute, Technion

Head, The Israeli Smart Transportation Research Center (ISTRC)

THE ISRAELI SMART TRANSPORTATION RESEARCH CENTER

NSL colloquium

Transport planning: Where do we go now?

Zurich, Dec 8, 2023

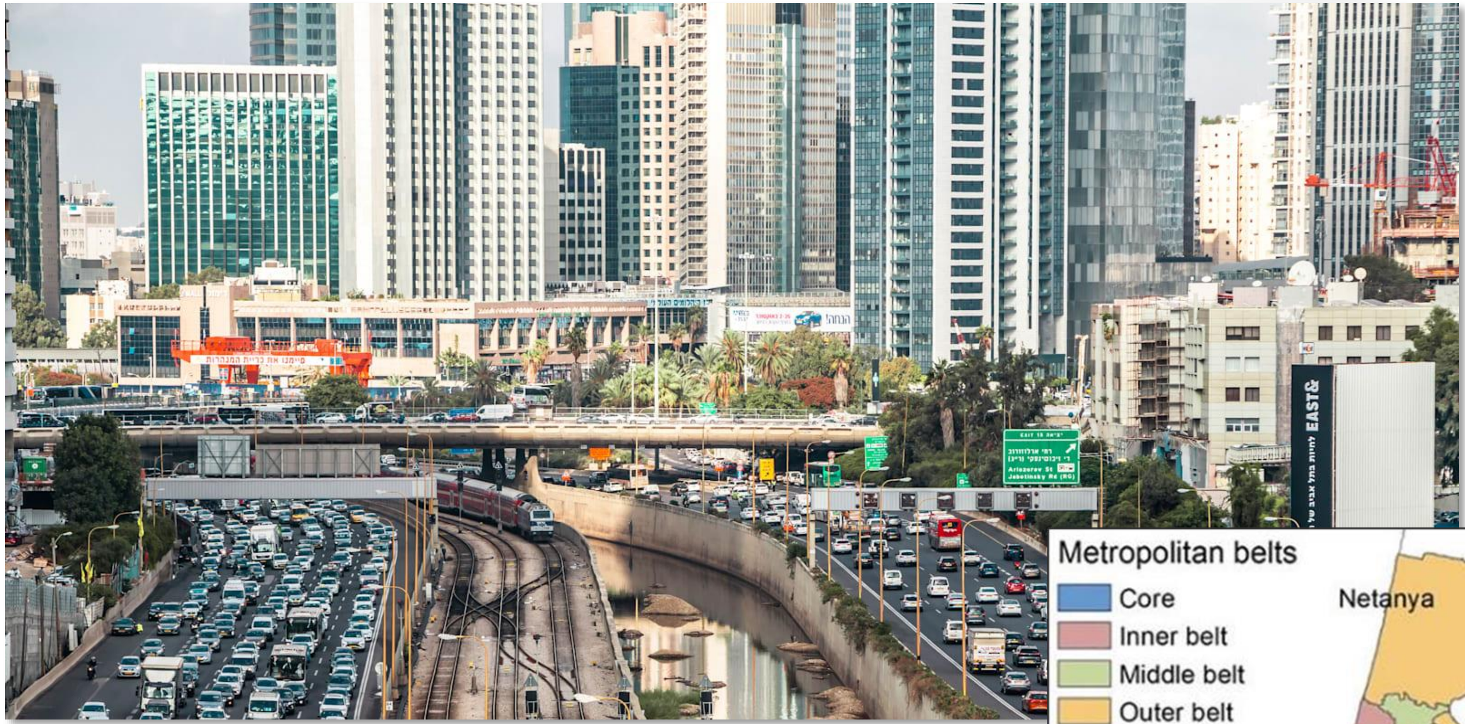
Outline

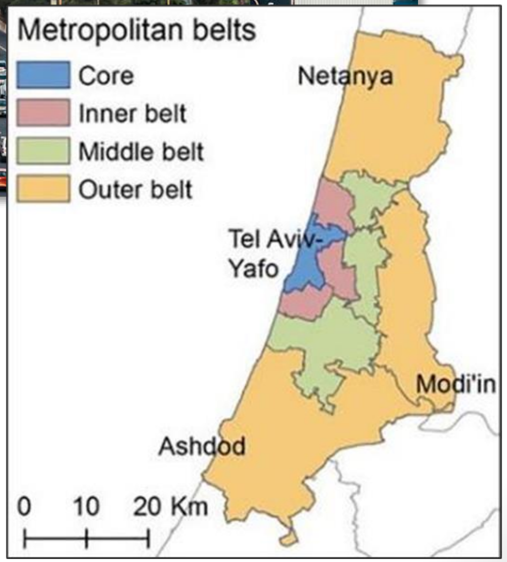
- Motivation: Tel-Aviv Metro Case Study
- The critique: Covid and Technology
- Behavior is the Key
- COVID impacts
- Technology
  - The technology hype
  - Behavior modelling challenges
  - Typology of approaches
  - Key behavioral findings
  - Congestion pricing and the metro
  - Policy implications
- Mobility and the city in 2100

Motivation: Tel-Aviv Metro Case Study

- Population: 4 Million
- 44% of the population and 50% of the employment in Israel
- One of the most congested metropolitan areas in the world (21st according to TomTom).
- Population growth rate 2% in the last decade
- Estimated population in 2040: 5.4 Million
- In Europe, there is no metropolitan over 3 Million without a Metro.

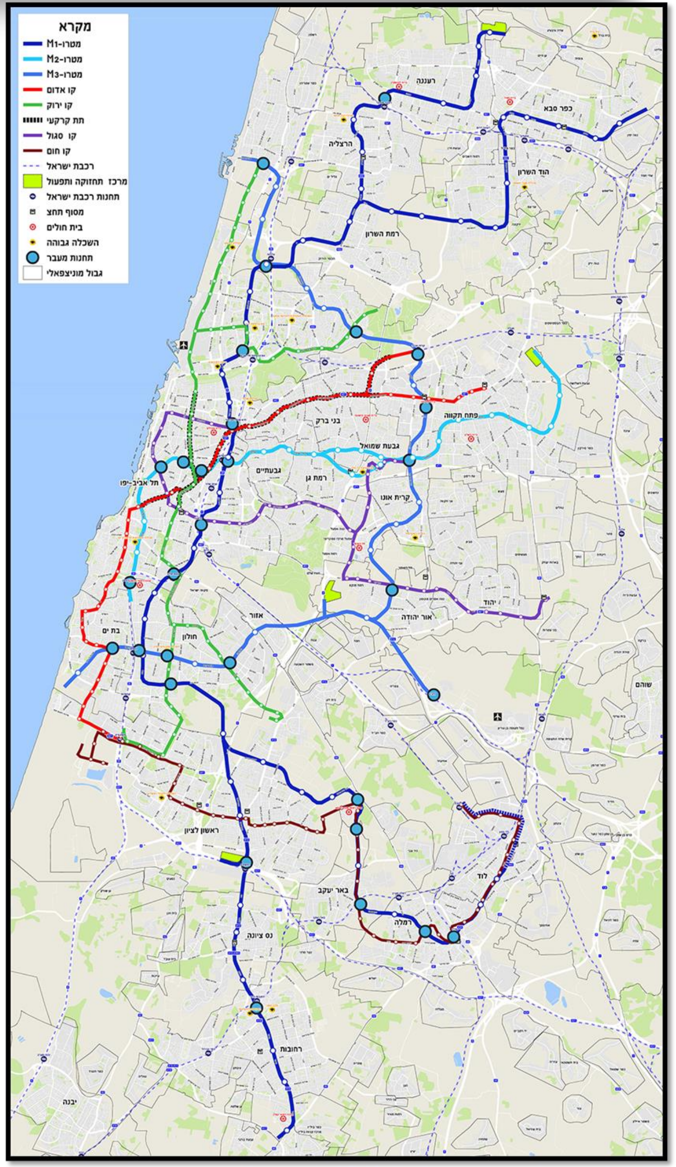
➡ **So, do we need a Metro?**





Tel-Aviv Mass Transit Plan

- A metro system of 3 lines serving the Core, Inner Ring and Middle Ring
- 3 LRT lines: Red (recently opened), Green and Purple (under construction)
- 3 BRT lines
- Suburban rail lines



Tel-Aviv Mass Transit Plan

- A metro system of 3 lines serving the Core, Inner Ring and Middle Ring
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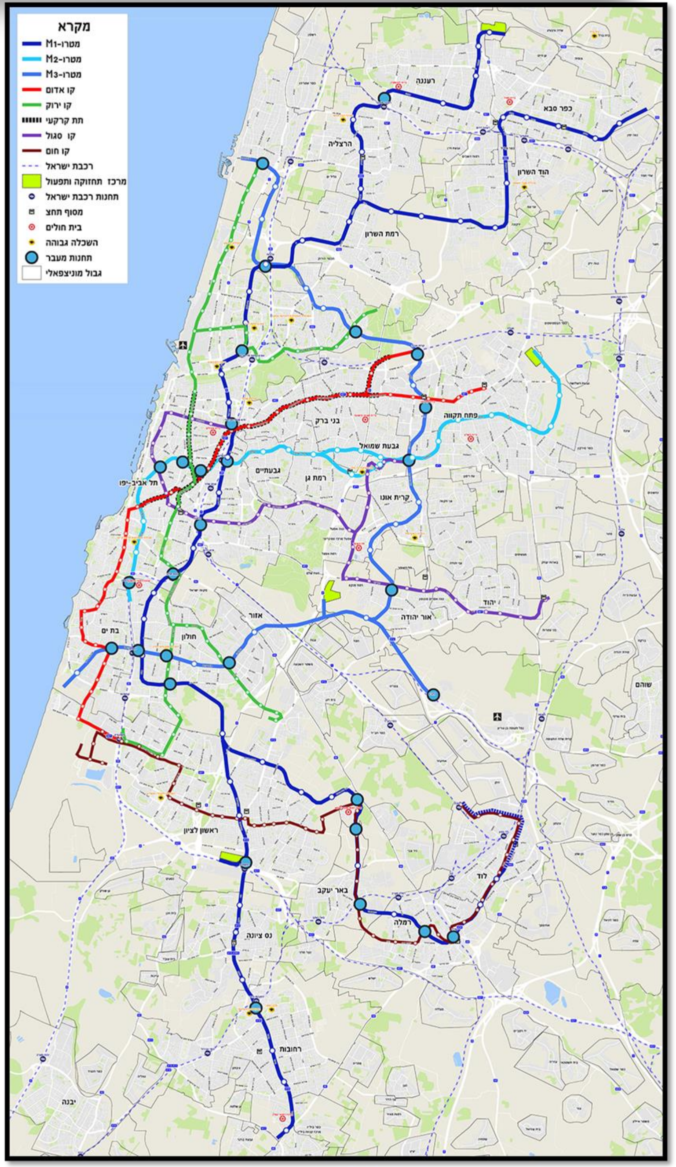
- 3 BRT lines
- Suburban rail lines

Cost:
€50 billion



The Critique:

From COVID-19 to Technology

Behavior is the Key

Can be a SILVER BULLET: All will share…..

- Work from home and other digital activities
- Less car ownership, more sharing, use of MASS
- Higher capacity, more efficient supply, traffic flow

Can result in HELL: All will travel more…..

- Increased VMT
  - New modes of travel, heaper and more convenient travel, multi-tasking, Value of Time (VOT)
- New population groups who can travel by car
- Reduce transit use
- Escalating on-demand delivery
- Further suburbanization

Behavior is the Key

Hörl, S., Ciari, F., & Axhausen, K. W. (2016). Recent perspectives on the impact of autonomous vehicles. *Arbeitsberichte Verkehrs-und Raumplanung*, 1216.

AV impacts

induced demand | congestion | lower speeds | higher travel times | higher delivery demand

increased accessibility | efficient deliveries

COVID Impacts

Hintermann, B., Schoeman, B., Molloy, J., Schatzmann, T., Tchervenkov, C., & Axhausen, K. W. (2023). The impact of COVID-19 on mobility choices in Switzerland. *Transportation Research Part A: Policy and Practice*, 169, 103582.

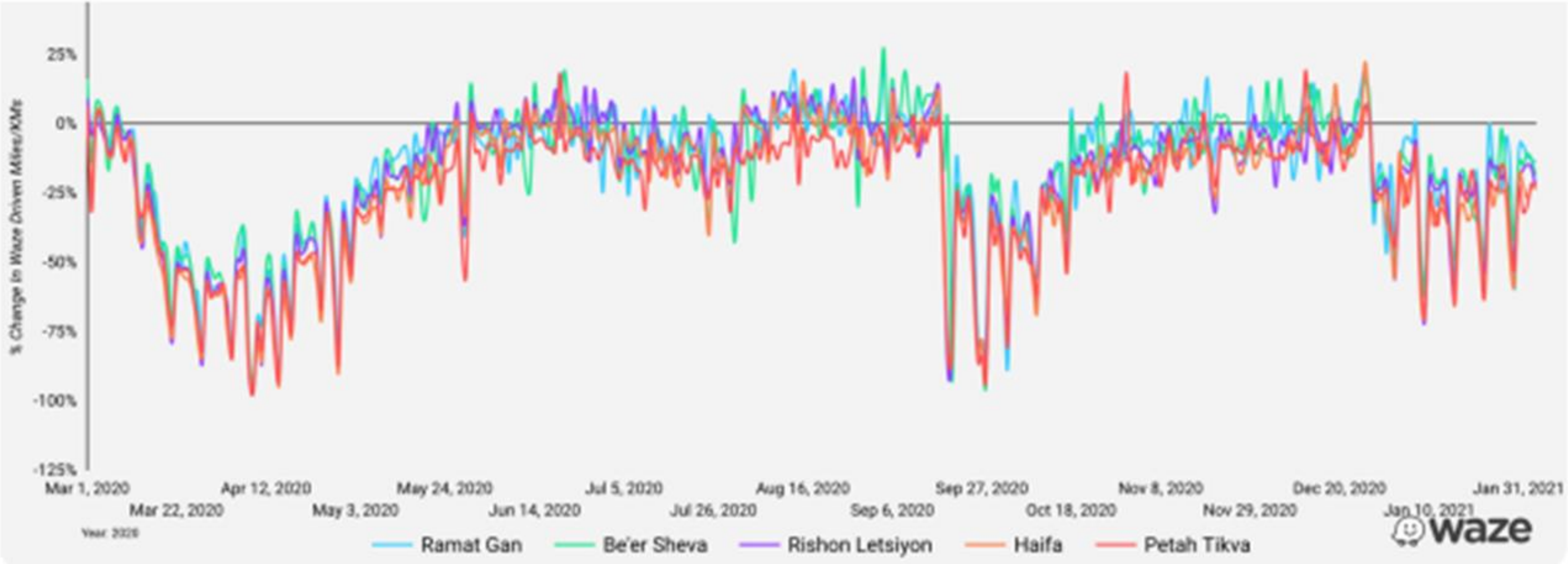
Du, W., Winkler, C., & Axhausen, K. W. (2021). How did COVID-19 shift time use patterns in Switzerland?. Arbeitsberichte Verkehrs-und Raumplanung, 1652.

Before/after pandemic comparison using tracking app & survey (3,700 participants):

- **Pandemic onset:**
  - 60% distance traveled (km/day) reduction (all modes, but less for walking)
- **After pandemic (May 2021):**
  - Travel distances regain pre-pandemic levels, but public transport ridership is still at 40% of the pre-pandemic rate
  - Mode share, purpose share, and travel patterns have significantly changed

COVID Impacts on Traffic

As lockdowns are lifted, car trips tend to return to pre-COVID levels (Waze, 2021)



Joint Israel-Czech Research

Shiftan, Kogus, Gal-Tzur, and Brůhová-Foltýnová, 2022 (Working Paper)

First lockdown

April-May 2020

First Survey

- Personal data
  RP – Before COVID
- RP/SP – While lockdown
- SP – After pandemic

2,400 Participants

June 2020

Second Survey

- RP – After first lockdown
- SP – After pandemic

2,000 Participants

July 2022

Third Survey

- Changes in personal Data
- RP – After lockdown

1,070 Participants

Relevant Set (workers who answered all three surveys):
860 participants

Joint Israel-Czech Research

Shiftan, Kogus, Gal-Tzur, and Brůhová-Foltýnová, 2022 (Working Paper)

Remote work/study (from home)

Weekly time (Hr)	**RP pre-COVID**	**SP for after COVID June 2020**	**RP post-COVID June 2022**
0	469	402	328
0-5	163	137	96
5-10	91	126	136
10-20	56	77	120
20-30	26	47	79
30-40	25	34	59
40+	30	37	42
Total	**860**	**860**	**860**

RP pre-COVID

55%

did not work from home

SP for after COVID

46%

said they will not work from home

RP post-COVID

38%

not working from home at all

More people combine remote working than excepted!

On average work at home increased from 5.6 to 10 Weekly hours

Joint Israel-Czech Research

Workdays out of home (per week)	RP pre-COVID	RP post-COVID	Diff (%)
0	78	73	-6%
1	30	63	110%
2	36	85	136%
3	58	107	84%
4	66	127	92%
5	503	324	-36%
6	69	62	-10%
7	20	17	-15%

AVG = 4.2 Days AVG = 3.7 Days

- 13% average decrease of workdays out of home
- More participants combine remote working
- Significant decrease among those who work 5 days at the office

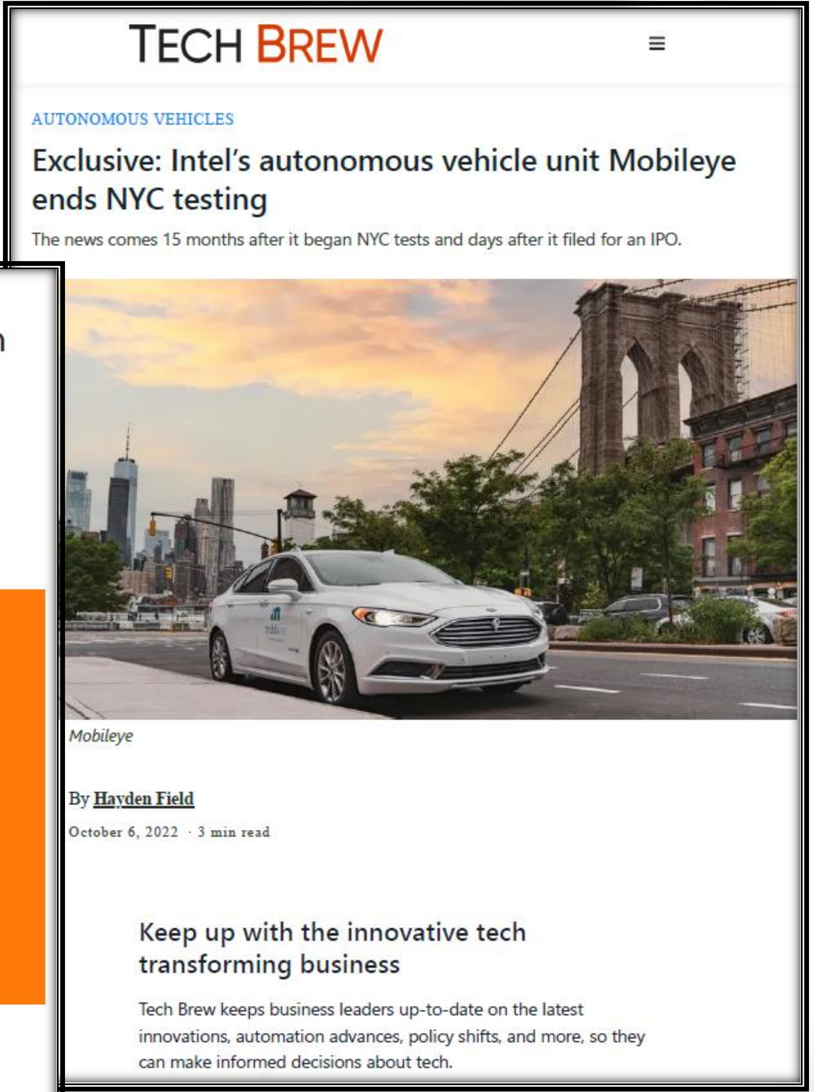
Technology

- Electrification
- Automation
- Connectivity
- Mobility as a Service (MaaS)

The Hype

The hype cycle around AVs:

- Reached its maximum expectations in 2015
- For the full benefits we need all level 5, would we ever get there?



TECH BREW

AUTONOMOUS VEHICLES

Exclusive: Intel's autonomous vehicle unit Mobileye ends NYC testing

The news comes 15 months after it began NYC tests and days after it filed for an IPO.

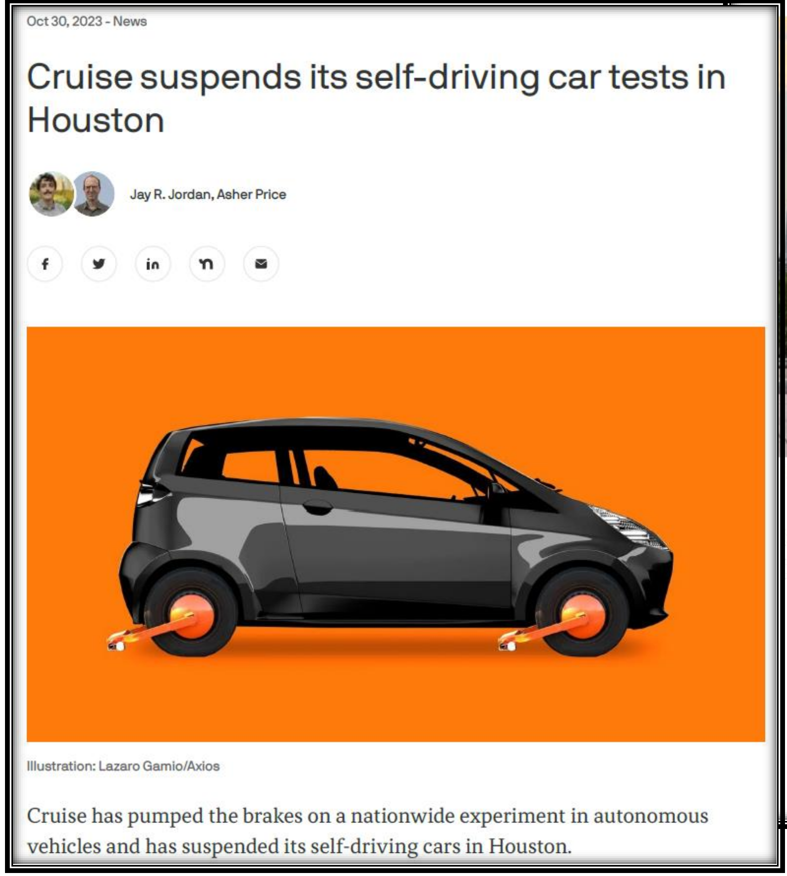
Mobileye

By Hayden Field

October 6, 2022 · 3 min read

Keep up with the innovative tech transforming business

Tech Brew keeps business leaders up-to-date on the latest innovations, automation advances, policy shifts, and more, so they can make informed decisions about tech.



Oct 30, 2023 - News

Cruise suspends its self-driving car tests in Houston

Jay R. Jordan, Asher Price

Illustration: Lazaro Gamio/Axios

Cruise has pumped the brakes on a nationwide experiment in autonomous vehicles and has suspended its self-driving cars in Houston.

Behavioral Modeling Challenges

Security Nightmare of Driverless Cars

TRIPWIRE GUEST AUTHORS (HTTP://WWW.TRIPWIRE.COM/STATE-OF-SECURITY/CONTRIBUTORS/GUEST-AUTHORS/)
OCT 25, 2015 | FEATURED ARTICLES (HTTP://WWW.TRIPWIRE.COM/STATE-OF-SECURITY/TOPICS/FEATURED/)
(HTTP://WWW.TRIPWIRE.COM/STATE-

The Driverless Car Debate: How Safe Are Autonomous Vehicles?

By Lauren Keating, Tech Times | July 28, 9:00 AM

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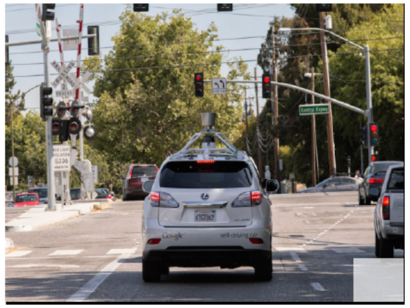


As companies like Google and Delphi Automobile continue to test autonomous vehicles on the road, issues concerning the safety in regard to accidents and vulnerability in the software continue to rise. How safe are autonomous cars? (Photo : Google)

When it comes to the future of transportation, the first thing comes to mind is the possibility of flying cars. It's easy to im an urban utopia with vehicles that float through the air, swer around buildings, reaching toward the heavens.

While *Back to the Future: Part II* wrongly predicted that we w have this technology in 2015, autonomous vehicles—which currently being tested—may just be the stepping stone to m this a reality. Who would've thought robot cars would be our present?

No matter what side you stand on in the safety debate, even those who have concerns still agree that this innovative technology is the way of the future.

Companies like Google, Delphi Automotive, Bosche, Tesla, Nissan Mercedes-Benz, Uber and Audi have already begun testing self-

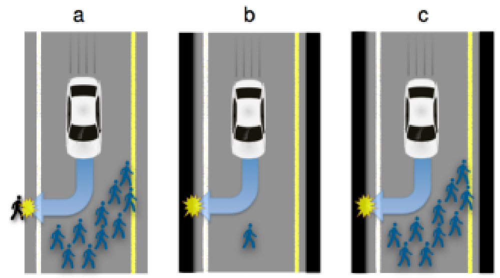
A View from **Emerging Technology from the arXiv**

Why Self-Driving Cars Must Be Programmed to Kill

Self-driving cars are already cruising the streets. But before they can become widespread, carmakers must solve an impossible ethical dilemma of algorithmic morality.

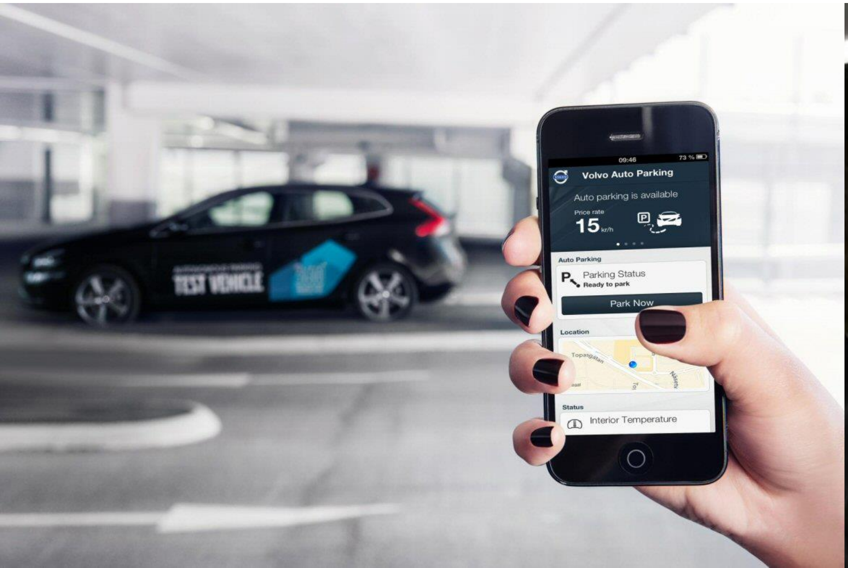
October 22, 2015

When it comes to automotive technology, self-driving cars are all the rage. Standard features on many ordinary cars include intelligent cruise control, parallel parking programs, and even automatic overtaking—features that allow you to sit back, albeit a little uneasily, and let a computer do the driving.



Efficient Use of Travel Time

- How can we adequately describe and measure **alternative time use**?
  (including productivity improvements and other activities performed during travel)
- Extended time allocation models: Impact on **VOT**



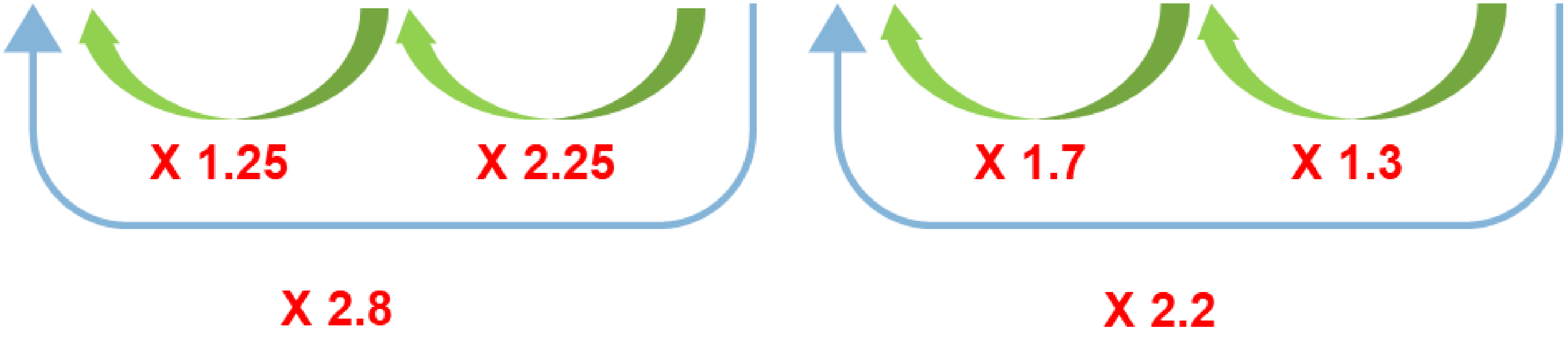
Bergman and Shiftan (Working Paper): RP-SP Study

- RP for current commute trip with 3 alternatives: Private car (PC), car passenger (CP), and rail.
- SP with 4 alternatives, adding automated vehicle (AV).
- Estimating multi-tasking propensity auxiliary models.

MNL	3A-M4			4A-M4			
	PC	CP	RAIL	PC	CP	RAIL	AV
Time	-0.085*** (-7.64)	-0.106*** (-13.00)	-0.09*** (-11.18)	-0.086*** (-6.65)	-0.0817*** (-9.15)	-0.078*** (-10.47)	-0.0825*** (-7.86)
Cost	-0.033*** (-4.54)	-0.052*** (-9.25)	-0.097*** (-6.63)	-0.016*** (-2.19)	-0.026*** (-3.72)	-0.032** (-1.98)	-0.026*** (-5.17)
Prop_Eat	-	**2.47*** (7.37)**	**0.68*** (2.42)**	-	**1.51*** (5.88)**	**0.88*** (3.26)**	-
Prop_Laptop	-	-	**1.16*** (2.96)**	-	-	**1.24*** (3.60)**	-
Prop_Read	-	-	-	-	**-1.07*** (-3.02)**	-	-
Prop_Rest	-	**0.86*** (3.21)**	-	-	**1.36*** (6.33)**	-	-
Prop_Call	**1.09*** (3.26)**	-	-	**1.20*** (3.54)**	-	-	-

Bergman and Shiftan (Working Paper): Values of Time

MNL	3A-M4			4A-M4			
	PC	CP	RAIL	PC	CP	RAIL	AV
VOT (NIS/hr)	~ 154	~ 123	~ 55	~317	~188	~145	~189



Bergman and Shiftan: Values of Time

VOT (NIS/Hr) by propensity to multi-task:

	Private car	Car passenger	Rail
High propensity	42	37	34
Low propensity	117	150	70

Impact on Behavior

- Ownership/use
- Activity participation
- Destination choice
- Mode choice
- Land use/residential choice
- New car users

Typology of Approaches

1. Perform simulation based/scenario analysis studies
2. Stated Preference (SP) surveys
3. Virtual reality/games/simulators
4. Revealed Preference (RP)/analog modes/naturalistic experiments/chauffer
5. Panel/longitudinal analysis
6. Qualitative/focus groups/in-depth interviews
7. Integrated approaches: Data/disciplines

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So, what do we know about behavior so far?

Industry’s Perspective

“Car ownership will all-but end in cities by 2025”

“Peak car ownership in the US will occur around 2020 and will drop quickly after that… Automated mobility services could capture 2/3 of the US mobility market in 15-20 years”

Current reality

Some Case Studies

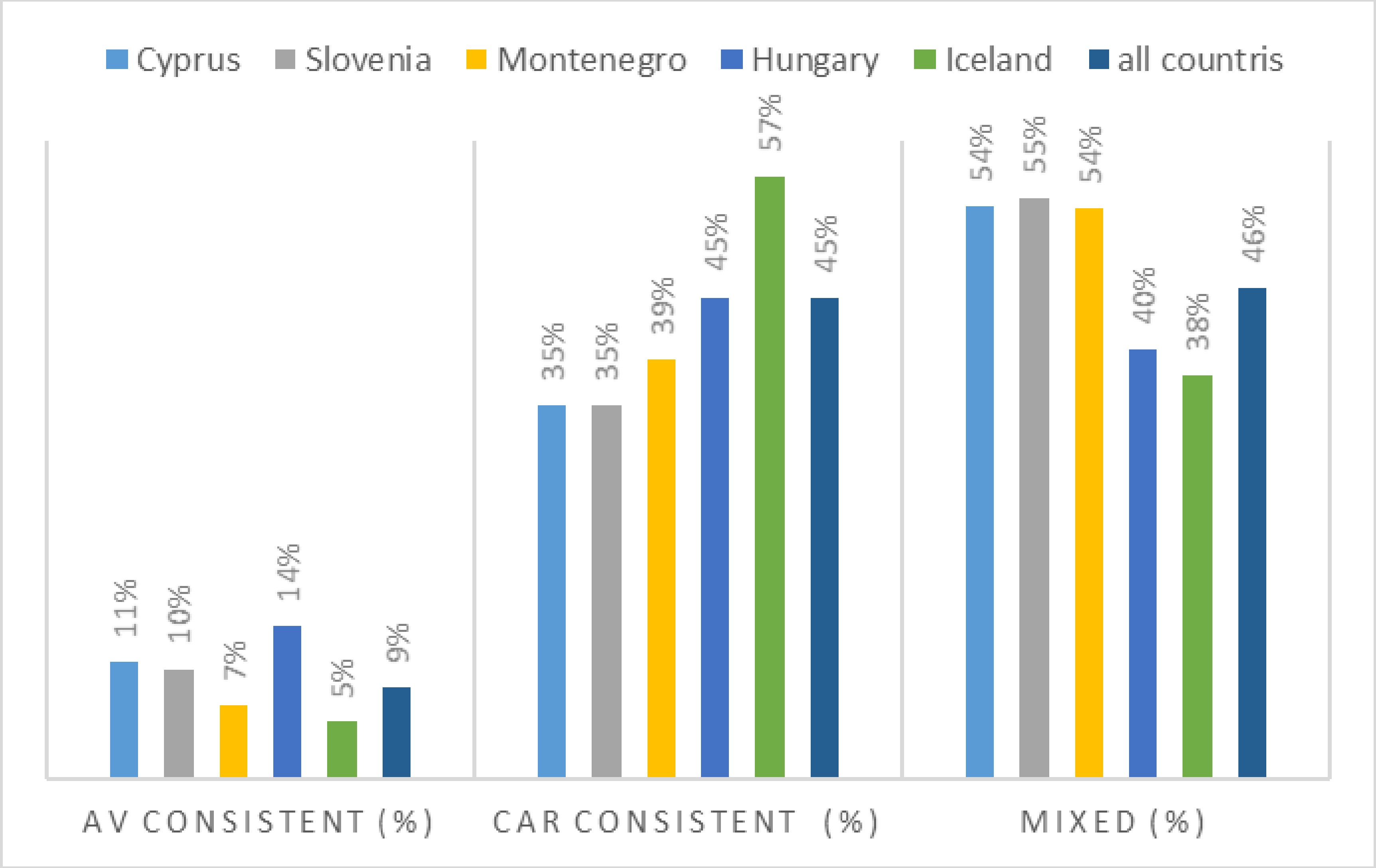
The case of ride-hailing services:

- Denver, Colorado study (Henao & Marshall, 2019):
  - Uber average vehicle occupancy is 0.8
  - Ride-hailing leads to 83.5% more VMT than if not existed
- The case of NY subway (Schaller Consulting, 2017)
  - 2016 was the first year subway total ridership went down with an increase of 7% in VMT

Willingness to share:

- “the shared mobility lie” (Currie, 2018)
- Transit is the most sharable mode

Wise Act Survey: Consistent Choices



SP survey

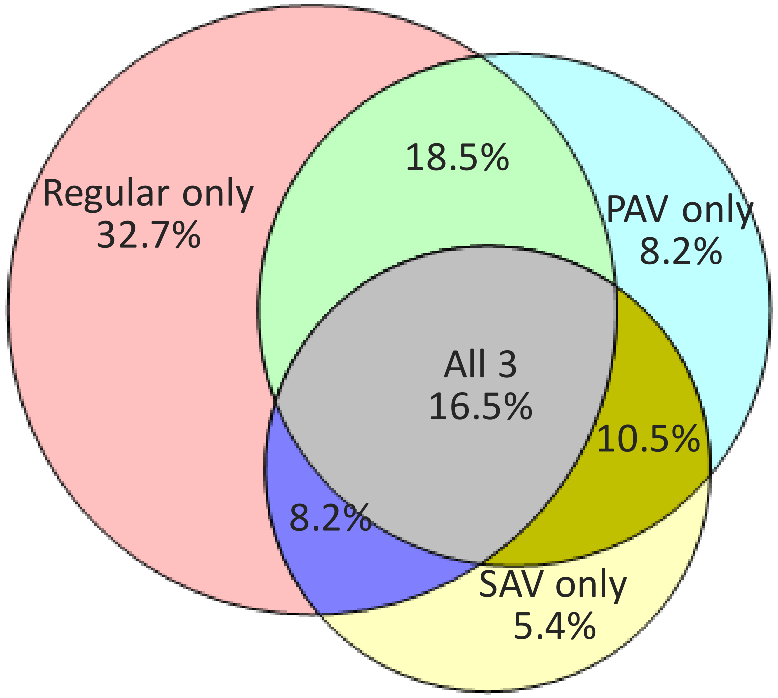
25 countries

4,000 respondents

Etzioni, Shiftan, et al., "Modeling Cross-National Differences in Automated Vehicle Acceptance" *Sustainability*, 12(22), 2020

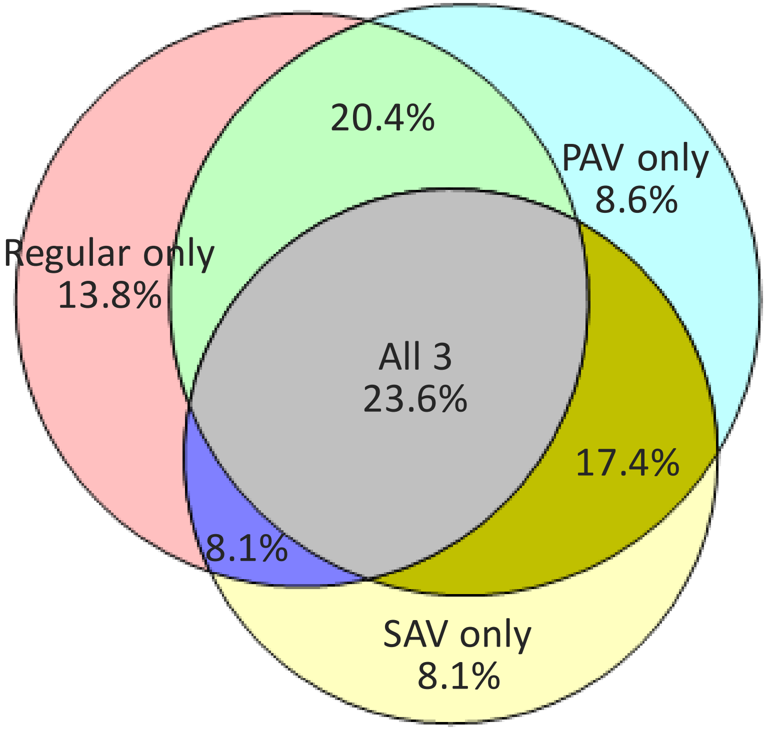
Consistent Individuals

North American individuals



59.4% non sharing

Israeli individuals



42.8% non sharing

Haboucha, C. J., Ishaq, R., Shiftan, Y., “User preferences regarding autonomous vehicles”, *Transportation Research C* No. 78, pp. 37-49, 2017.

Key Behavioral Findings

Harb, Stathopoulos, Shiftan, and Walker (2021)

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

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What do we (Not) know about our future with automated vehicles?

Mustapha Harb [a,*], Amanda Stathopoulos [b], Yoram Shiftan [c], Joan L. Walker [d]

[a] *Department of Civil and Environmental Engineering, University of California at Berkeley, 116 McLaughlin Hall, Berkeley, CA 94720-1720, United States*
[b] *Department of Civil and Environmental Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208-3109, United States*
[c] *Department of Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel*
[d] *Department of Civil and Environmental Engineering, University of California at Berkeley, 111 McLaughlin Hall, Berkeley, CA 94720-1720, United States*

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Literature review
Simulation models
Stated preference surveys
Fields experiments

ABSTRACT

While research on developing and testing automated vehicle (AVs) technologies is well underway, research on their implications on travel-related behavior is in its infancy. The aim of this paper is to summarize and analyze literature that focuses on travel-related behavior impacts of AVs, namely levels 4 and 5, as well as highlight important directions of research. We review five methods used to quantitatively investigate these implications and how each method contributes to this literature: 1) controlled testbeds, 2) driving simulators and virtual reality, 3) agent-based and travel-demand models, 4) surveys, and 5) field experiments. We also present five critical research questions regarding the implications of AVs on the demand side of transportation and summarize findings from the current literature on: 1) what is the willingness to adopt the technology? and what are the impacts of the technology on 2) in-vehicle behavior? 3) value of time? 4) travel-related behaviors (activity pattern, mode, destination, residential location)? and 5) vehicle miles traveled (VMT)? Results can be divided into four categories. The first category corresponds to results on research questions with numerous data points where the *direction of the impact* is consistent across the literature, albeit the magnitude varies considerably. For instance, surveys indicate 19% to 68% of people are unwilling to adopt AV technology, a sentiment that is fading over time. Moreover, people prefer owning AVs over sharing them and don't believe their car ownership will decrease. Regarding VMT, most studies predict an increase that varies from a low of 1% to a high of 90% depending on the scenario and assumptions under study. The second category of findings corresponds to research questions with limited and consistent, albeit highly variable data points. For example, a few stated preference survey studies indicate that reduced stress and multitasking during travel will reduce the value of time between 5% and 90%. The third category of results is on research questions with a few but conflicting data points. For instance, surveys indicate that people (80% to 85%) do not believe their residential location will be impacted by the adoption of AVs. Some simulation studies, however, indicate that lower travel costs will drive people away from cities and into suburbs while other studies report the opposite.

Key Behavioral Findings (Harb et al., 2021)

- Population share unwilling to adopt AV technology: 19% to 68%.
- Average willingness to pay for AV technology ranges from $1,600 to $14,000, with up to 59% unwilling to spend anything ($0).

Multi-tasking

- Most people believe they will multi-task while riding AVs, while others (up to 46%) believe they will not. Two main factors to hinder multi-tasking in AVs:
  - Lack of trust in the technology
  - Motion sickness
- For those who will multi-task, the most popular in-vehicle **activities** will be talking to other passengers, texting/talking on the phone, and eating.
- The ability to multi-task/relax during the commute is found to reduce riders' **VOT**. This decrease varies by mode (AV, SAV, and pooled SAV), and ranges from 5% to 55%.

Key Behavioral Findings (Harb et al., 2021) - Continued

Residence location

- 80-85% of people do not believe their residential location will be impacted by AV adoption.
- In a private ownership scenario, people will move away from cities into suburbs, while the opposite is true in an SAV adoption model.

AV ownership

- People prefer owning AVs over sharing them, with pooled SAVs being the least favored alternative.
- People do not believe their car ownership will decrease when they will own AVs.

Key Behavioral Findings (Harb et al., 2021) - Continued

Impact on mode share

- 25% are not willing to use SAVs, even if they are completely free.
- Most studies report that AV technology will reduce **transit ridership** by 9% to 70%.

Impact on trips and VMT

- AV convenience is expected to:
  - increase the number of trips by 2.5% to 58%
  - increase the average trip length by 14% to 20%
  - increase VMT by a considerable large range of 1% to 90%

➡ **Requires behavioral change even under optimistic technology scenarios**

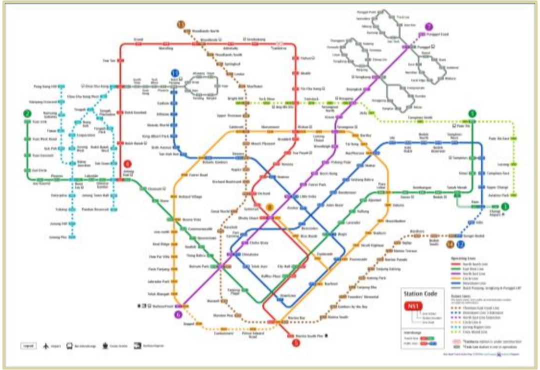
Congestion Pricing and the Metro

City	Starting year of congestion pricing	Total metro track length (Km)	Additional metro lines being planned
Singapore	1975	200	6
London	2003	402	5
Stockholm	2007	106	4
Milan	2008	97	5

Congestion Pricing and the Metro

Singapore

Population: 5.9 million (2023)



- Doubled its metro system in the past decade from 100 to 190 Km, investing $25 billion
- Currently planning 6 additional metro lines

Tel-Aviv

Population: 5.4 million (2040 estimate)

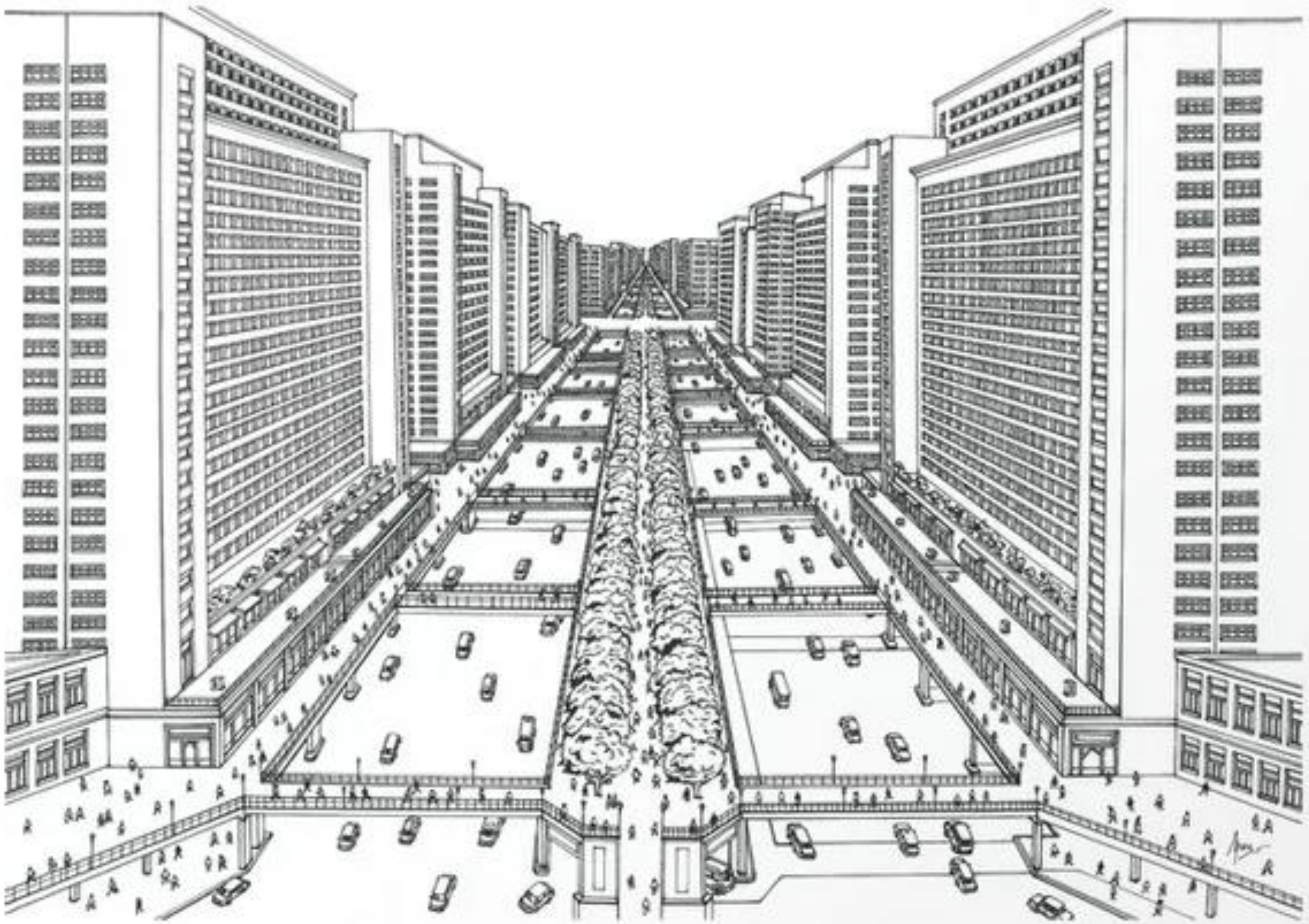
- Metro investment: €50 billion dollars for 140 Km of metro lines

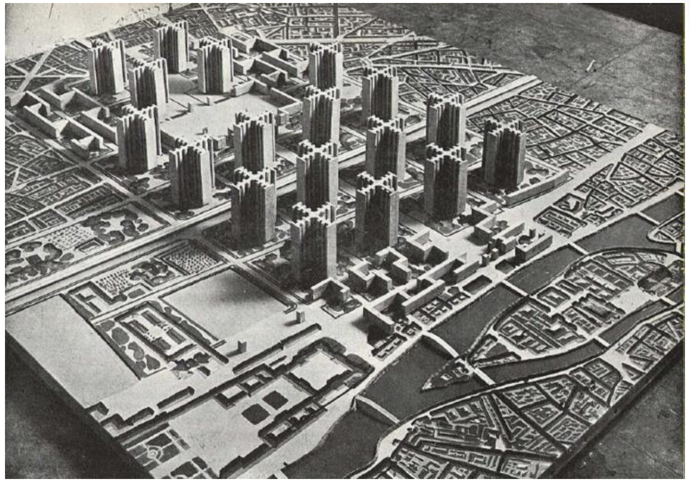
Re-thinking Transit Services - MAAS

- Mobility as a Service (MAAS)
- Mass transit services should be the core of MAAS.
- New mobility services should complement mass transit (last mile, access and egress, local trips), and policies and regulation should be designed to avoid competition with mass transit.
- Supporting policies:
  - Pricing
  - Specifically, by occupancy
  - Zero occupancy

Planners must consider taking actions today to prepare cities for driverless vehicles and sharing economy

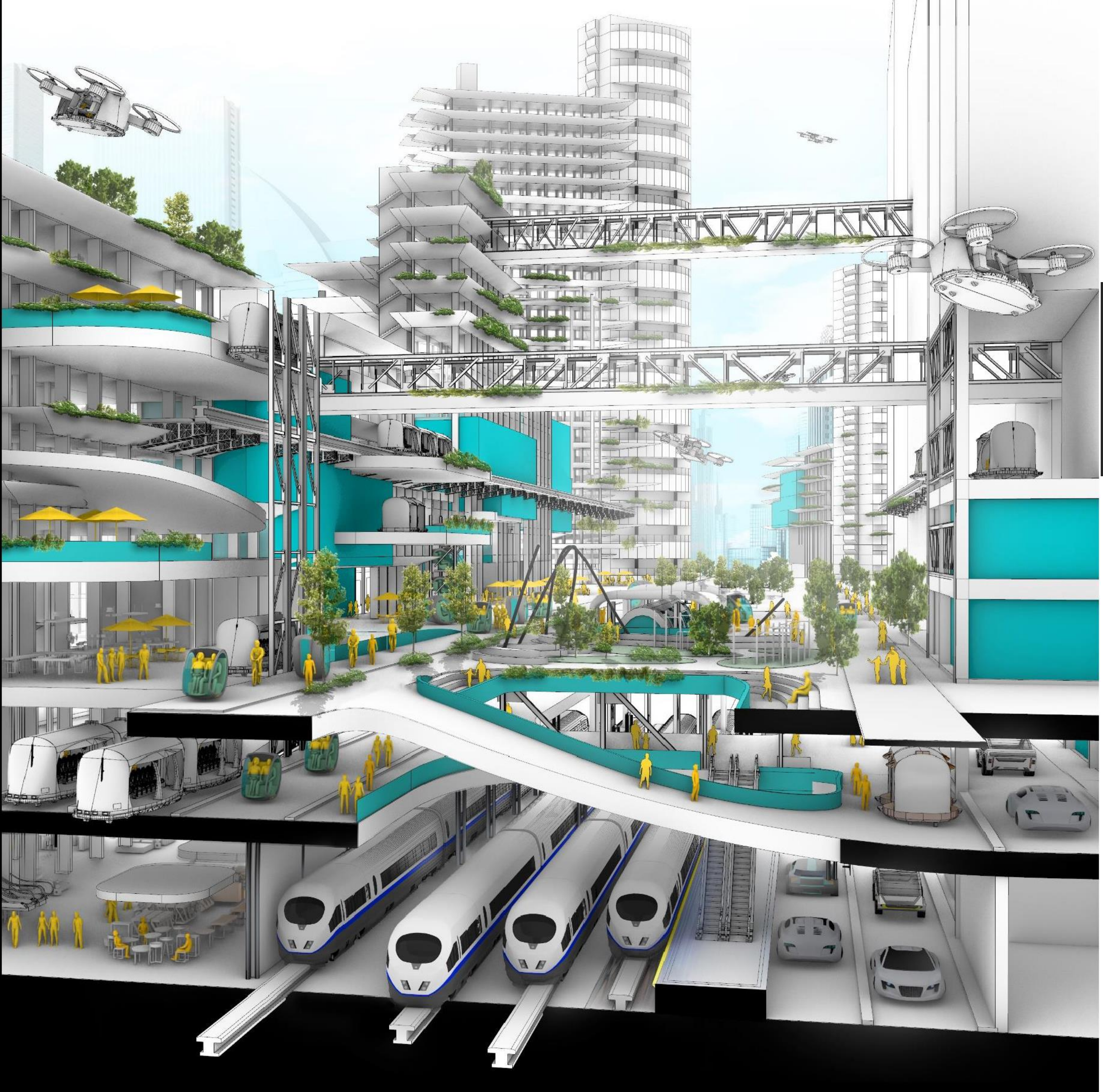

Meanwhile
in Tel-Aviv…





Le Corbusier proposed to demolish the city center of Paris to construct a series of modern high-rise apartments and office towers, connected by freeways and airports. This was intended to provide clean, comfortable housing for the masses.

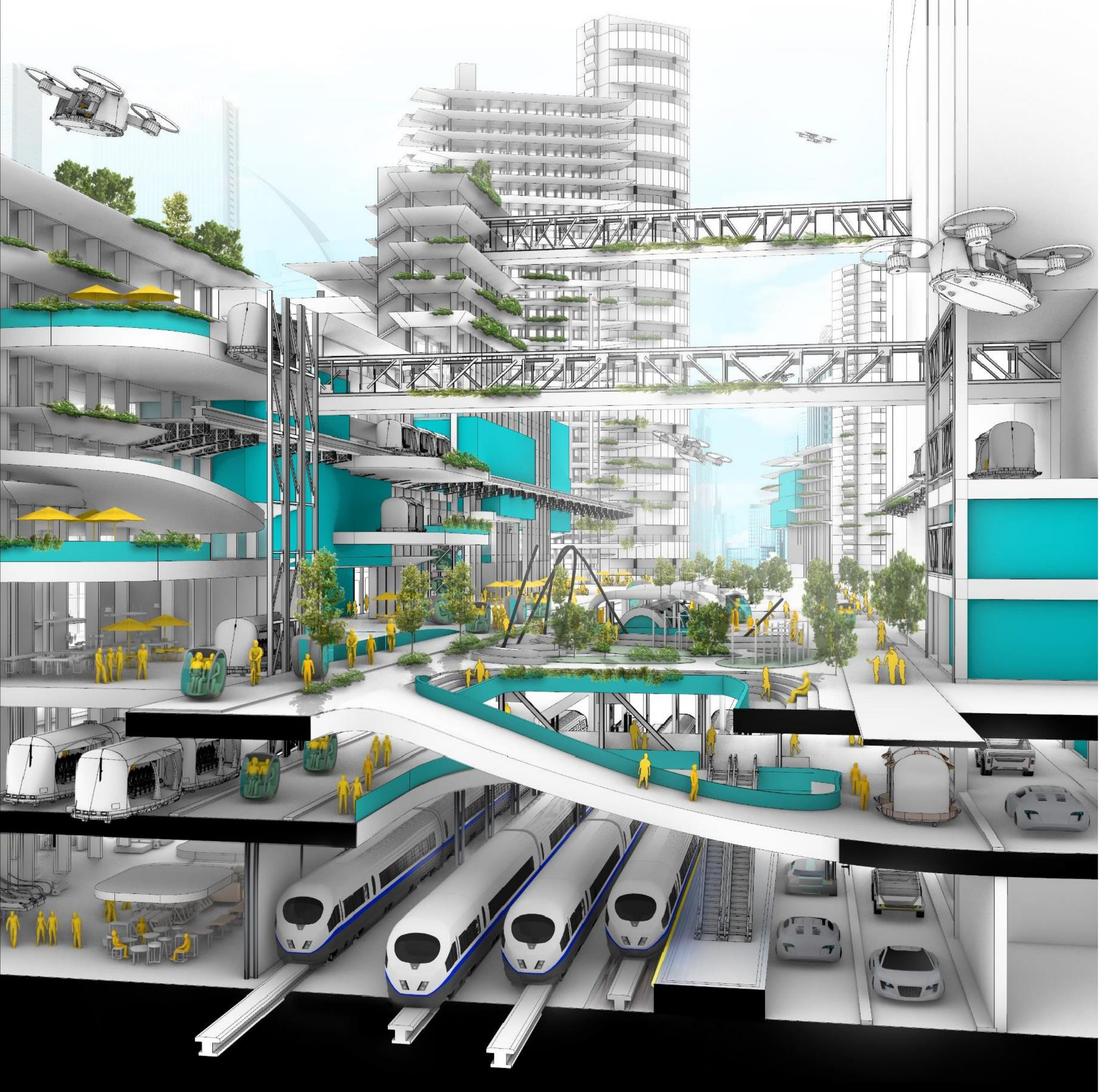
Le Corbusier, Ville Radieuse (the Radiant City), 1924



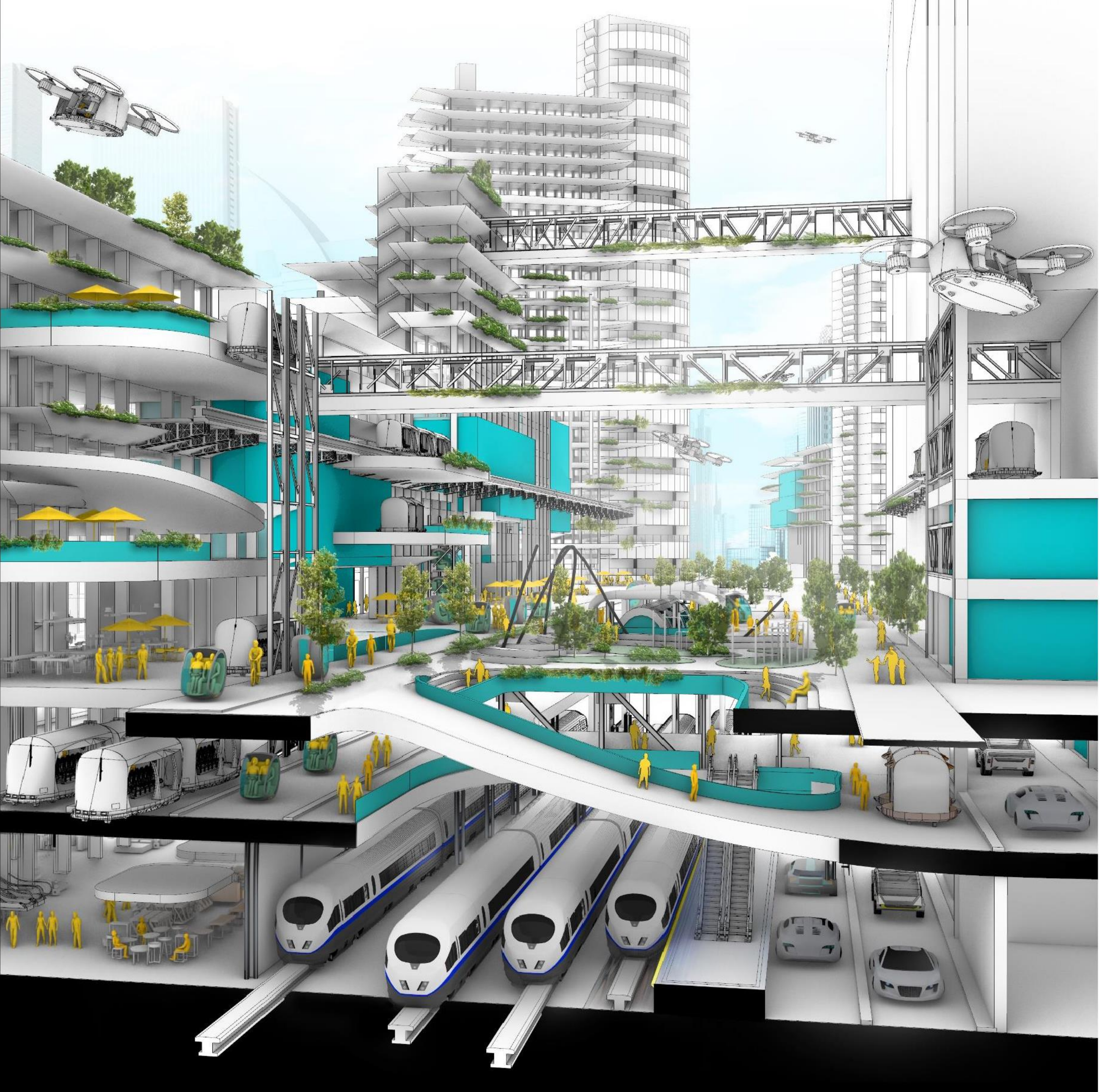
Mobility and the City in 2100

Yoram Shiftan and Alona Nitzan-Shiftan

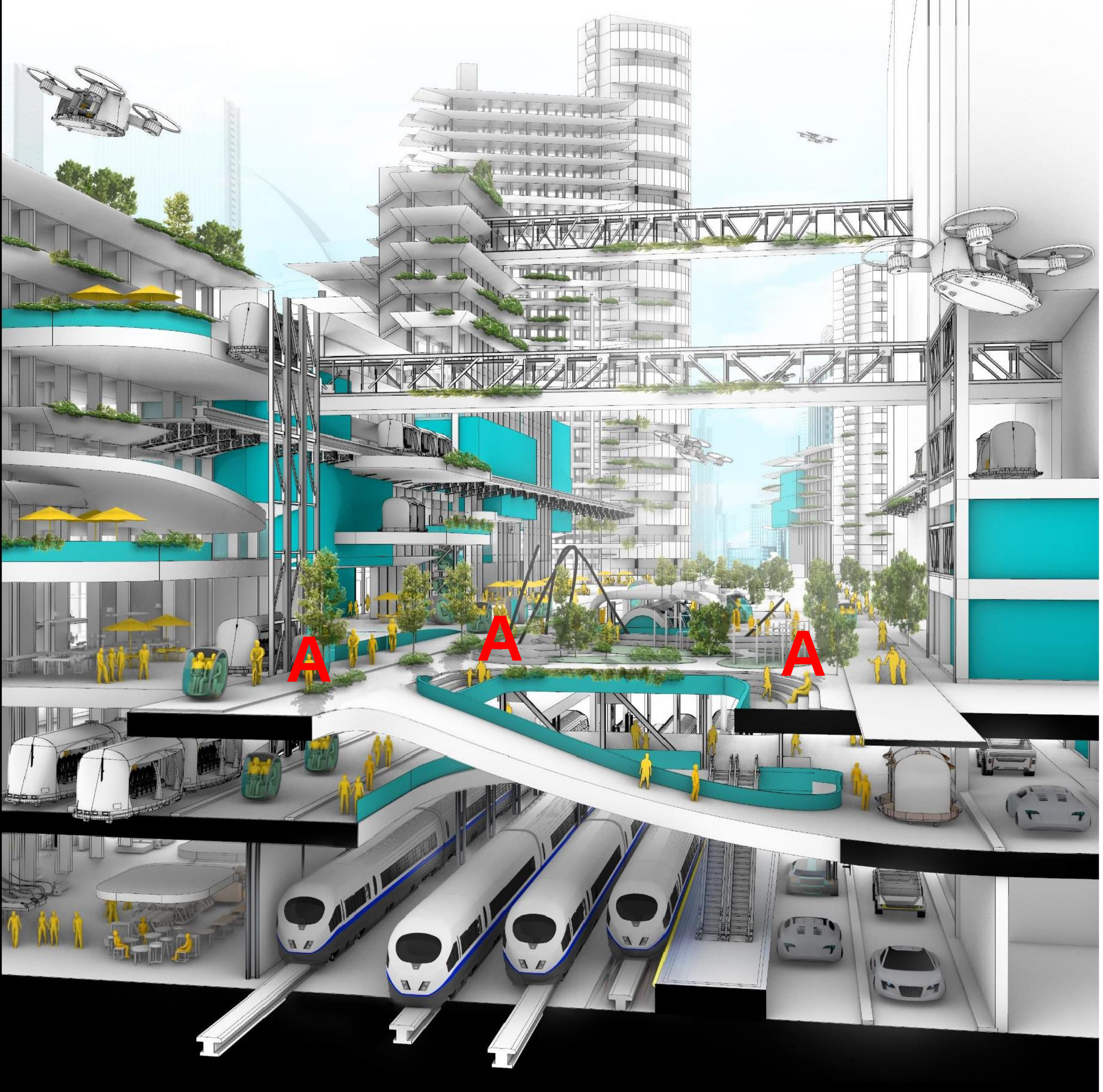
In: Derrible, S. & Chester, M.,
“Urban Infrastructure:
Reflections for 2100”



- **prioritizing people**! Use technology to enhance walkability
- The focal point is the viability of **pedestrian life**
- The existing city and its diverse uses are upgraded rather than replaced. It is **the future of an existing city**
- Connectivity between **a wide array of traffic modes/speeds**

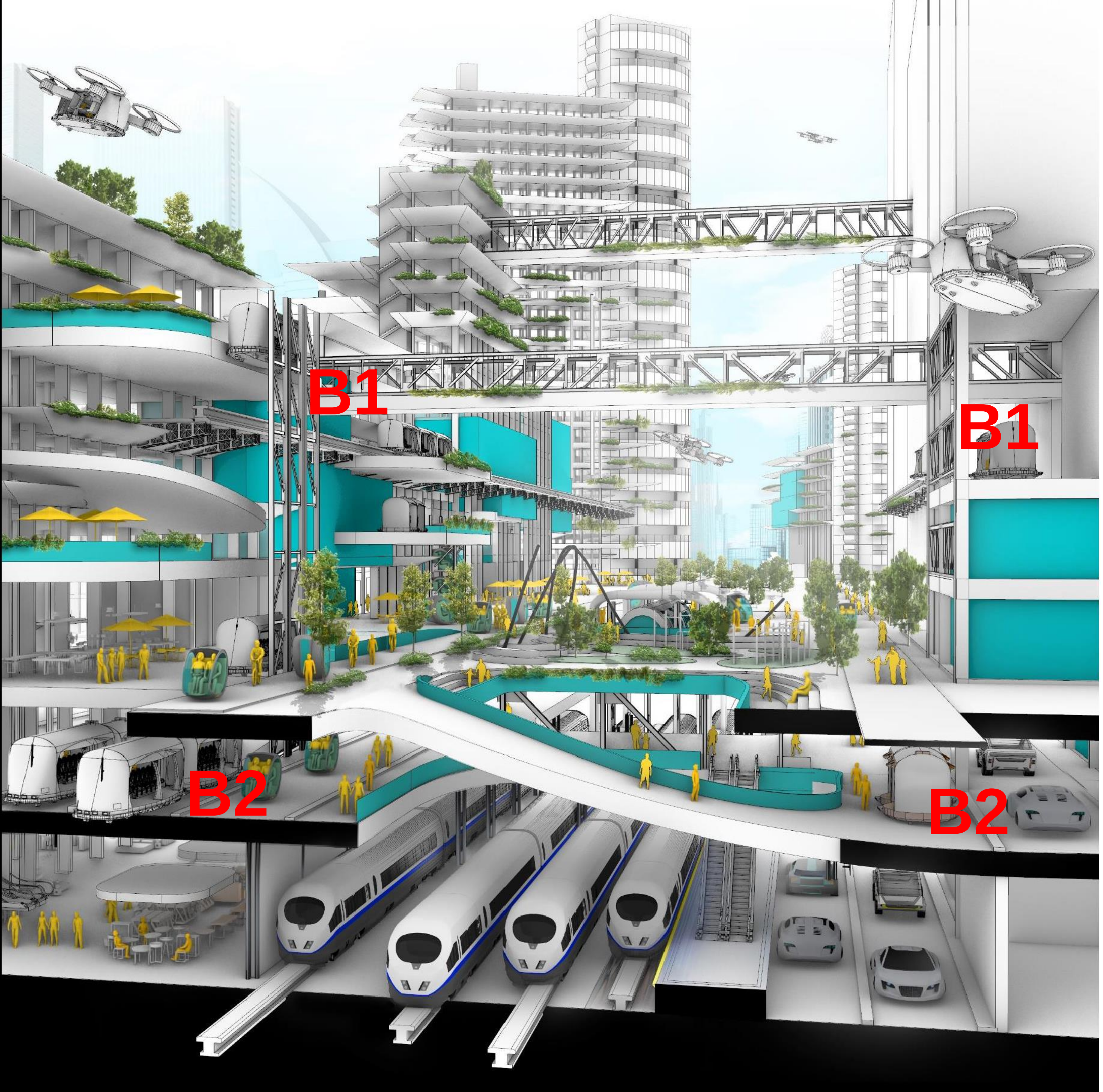


New technologies are **interwoven** into existing building surfaces, street spaces, and transportation infrastructures in a manner that respects the city form we know and cherish—major streets that envelope buzzing commercial activities.



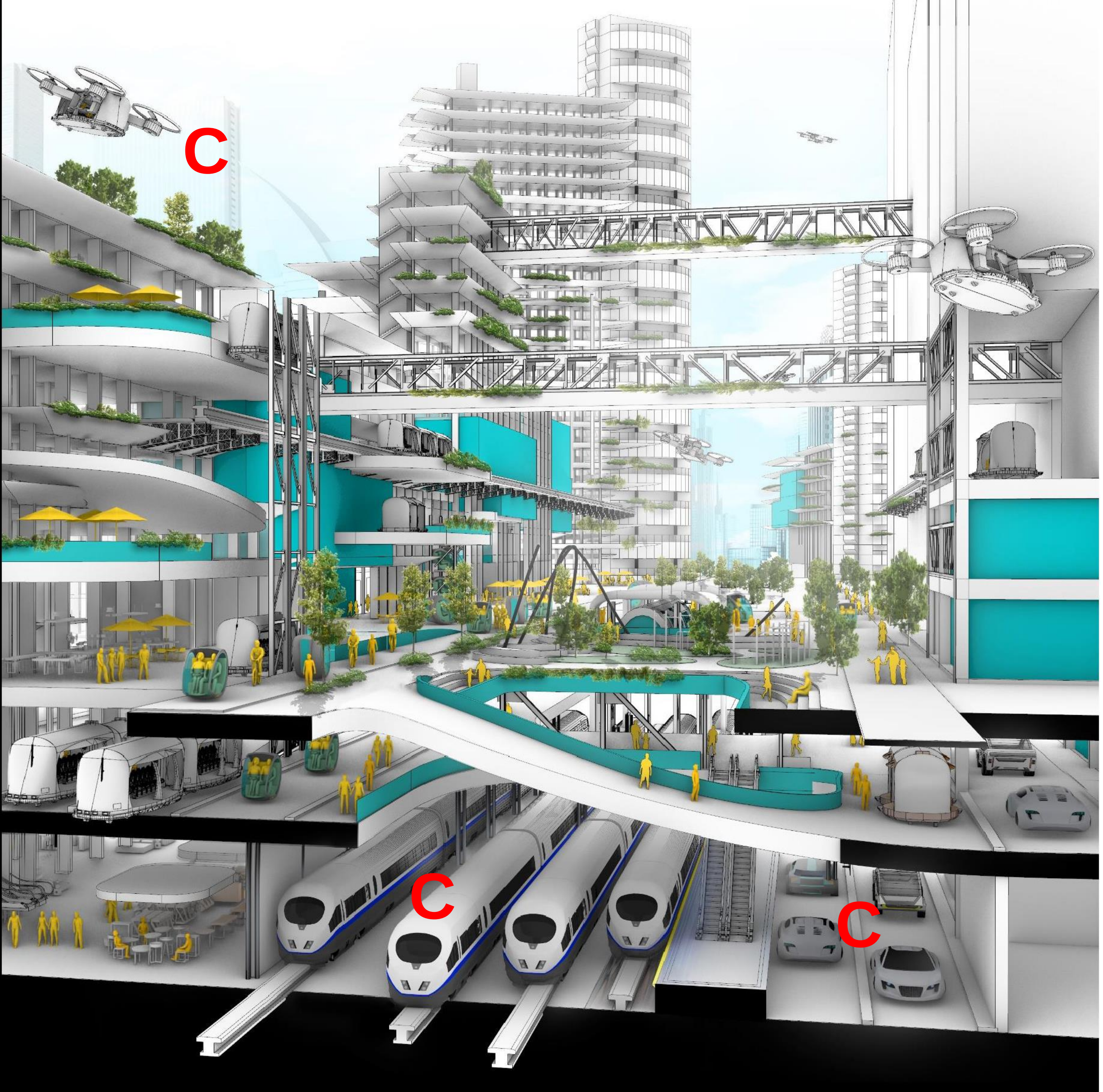
Zone A:

- Main street prioritizes pedestrians
- Micro-mobility on dedicated lanes



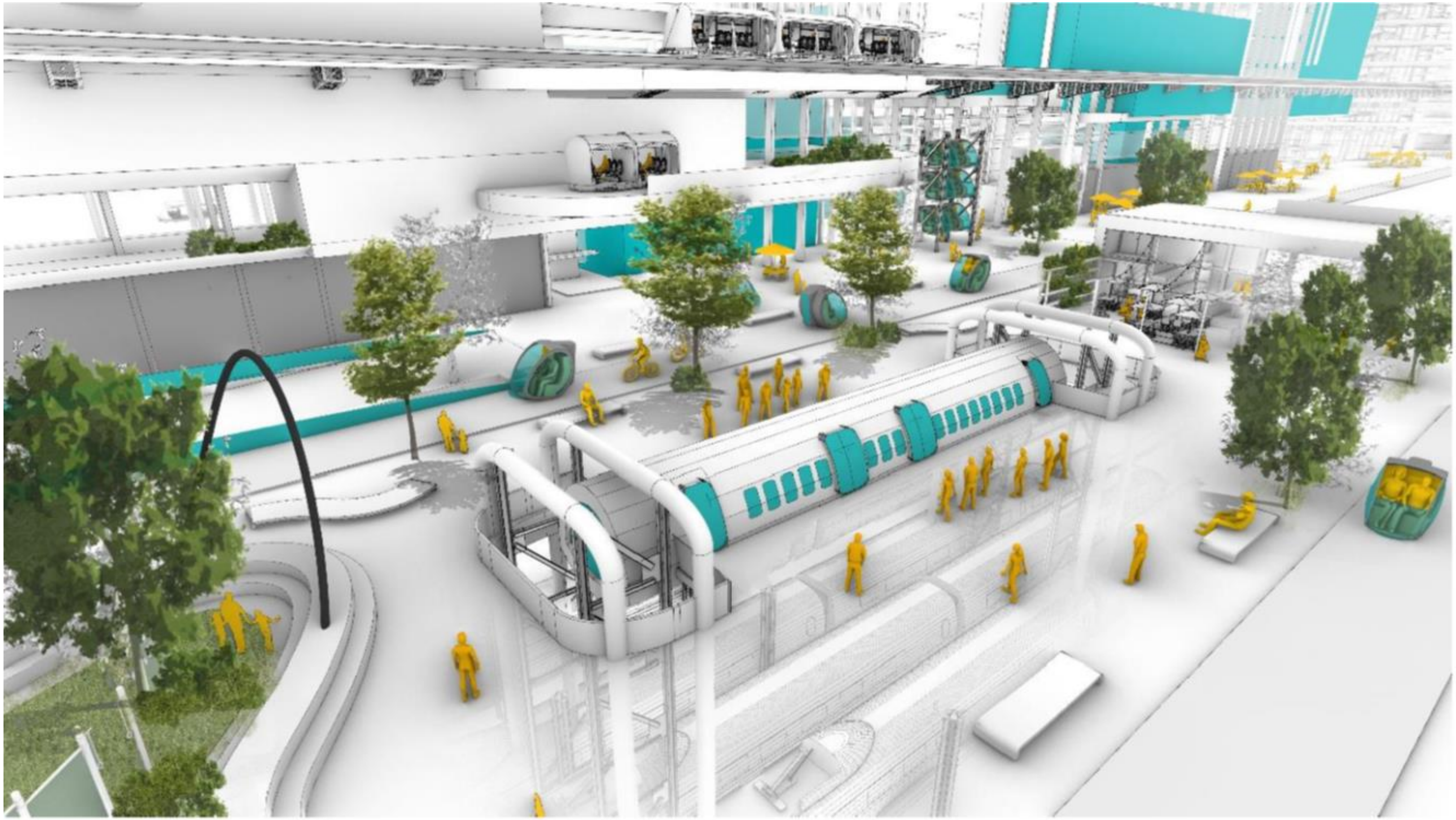
Zone B: Shared space

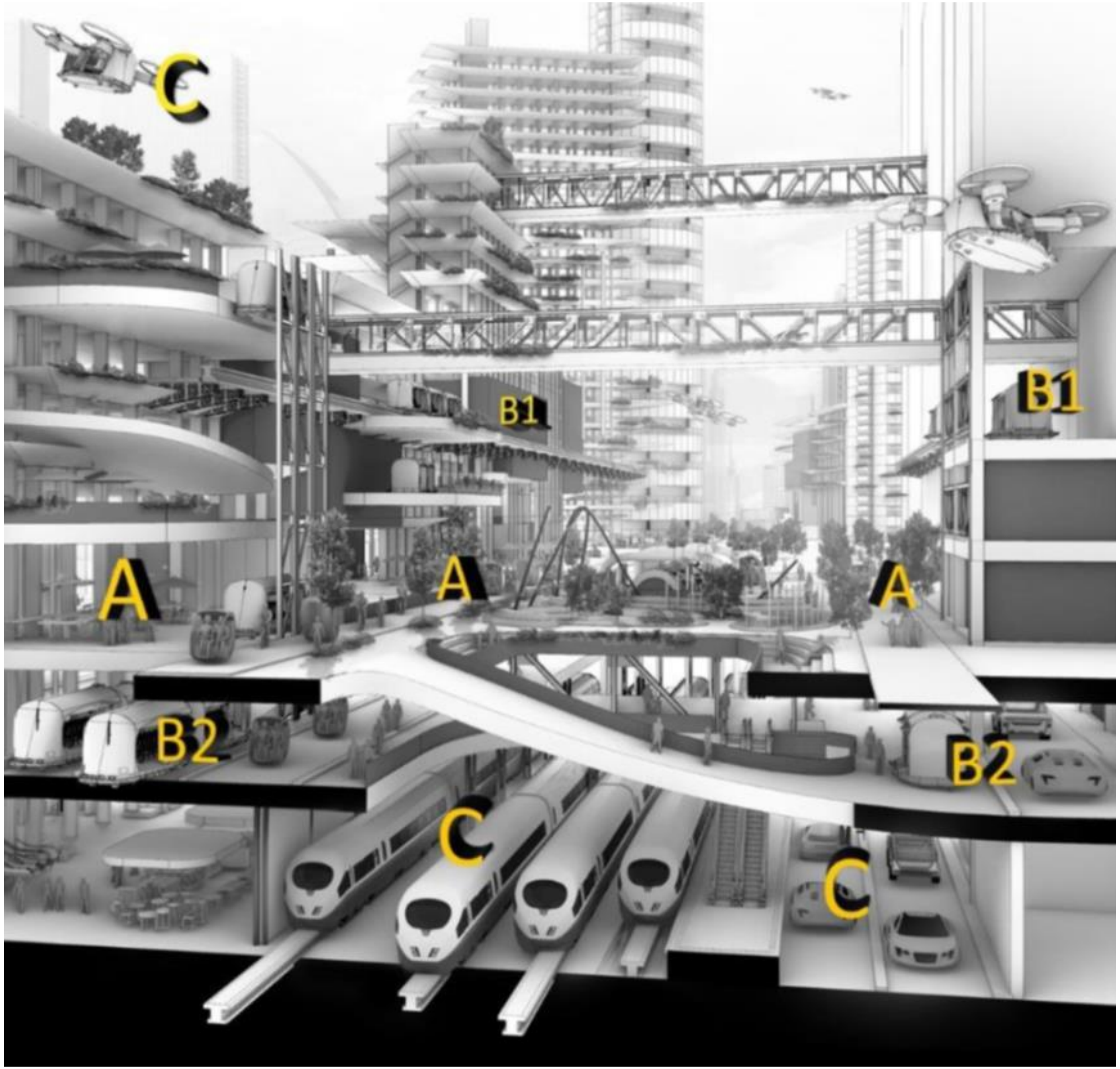
- Zone B1: Slow public services, speed limit 20 MPH
- Zone B2: Faster public transport, speed limit 40 MPH



Zone C: Fast lanes

- Metro and underground toll highways, Urban air mobility

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Thank you!

Yoram Shiftan

shiftan@technion.ac.il

Thank you!

Yoram Shiftan

shiftan@technion.ac.il

And thank you, Kay, for inspiring all these research activities!